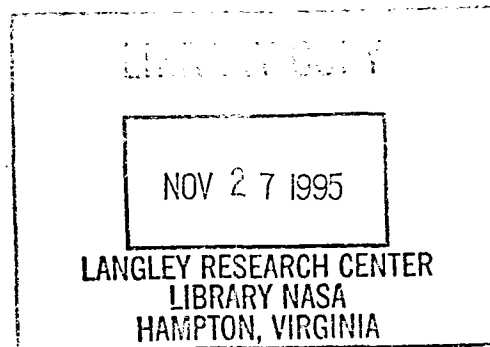




Debris/Ice/TPS Assessment and Integrated Photographic Analysis of Shuttle Mission STS-69

Gregory N. Katnik, Barry C. Bowen, J. Bradley Davis





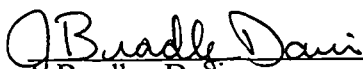
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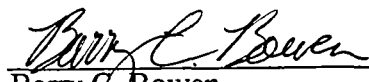
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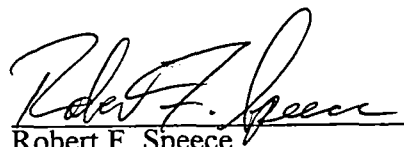
7 September 1995

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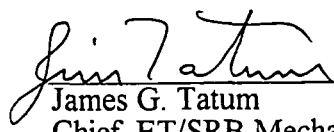

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FOREWORD

The Debris Team has developed and implemented measures to control damage from debris in the Shuttle operational environment and to make the control measures a part of routine launch flows. These measures include engineering surveillance during vehicle processing and closeout operations, facility and flight hardware inspections before and after launch, and photographic analysis of mission events.

Photographic analyses of mission imagery from launch, on-orbit, and landing provide significant data in verifying proper operation of systems and evaluating anomalies. In addition to the Kennedy Space Center Photo/Video Analysis, reports from Johnson Space Center and Marshall Space Flight Center are also included in this document to provide an integrated assessment of the mission.



Photo 1 : Launch of Shuttle Mission STS-69

1.0 SUMMARY

A launch attempt on 31 August 1995 was postponed due to an anomaly in fuel cell #1. The problem was detected prior to cryoload. Replacing the fuel cell caused the launch date to be reset for September 7th.

A pre-launch debris inspection of the pad and Shuttle vehicle was performed on 6 September 1995. The detailed walkdown of Pad 39A and MLP-1 also included the primary flight elements OV-105 Endeavour (9th flight), ET-72 (LWT 65), and BI-074 SRB's. There were no significant vehicle or facility anomalies.

The vehicle was cryoloaded on 7 September 1995. There were no Launch Commit Criteria (LCC), OMRS, or NSTS-08303 criteria violations. No IPR's were taken. As expected, there was no acreage ice or frost given the ambient weather conditions at this time of year. There were no protuberance icing conditions outside of the established data base.

The Final Inspection Team noted paper covers on Orbiter RCS thrusters L3D and L4L were tinted green indicating a small internal vapor leak. An ice/frost formation, approximately 1-inch in diameter, with venting vapors was located in an External Tank stringer valley at the LH2 tank-to-intertank flange closeout bondline just forward of the +Y bipod. The condition was found acceptable for flight. During GOX vent hood retraction, multiple areas of ET nose cone topcoat adhered to both GOX vent seals. One large area, measuring 3-inches long by 1.5 inches wide, was located on the northeast seal.

After the 11:09 a.m. (local) launch on 7 September 1995, a debris walk down of Pad 39A was performed. No flight hardware or TPS materials were found. There was no visual indication of a stud hang-up on any of the south holddown posts. All the T-0 umbilicals operated properly. Topcoat from the External Tank nose cone adhered to both GOX seals. (The seals stuck momentarily to the ET nose cone during vent hood retraction). Overall, damage to the launch pad was minimal.

A total of 122 films and videos were analyzed as part of the post mission data review. No vehicle damage or lost flight hardware was observed that would have affected the mission. SSME ignition appeared normal. Localized flow condensation collars on various parts of the vehicle were visible during ascent as expected for the warm, humid atmospheric conditions.

Orbiter umbilical camera films showed nominal separation of SRB's from the External Tank and normal separation of the ET from the Orbiter. A thin, metallic, 1/2-inch diameter washer originated from an area behind the LH2 ET/ORB umbilical cable tray after umbilical separation and drifted generally in the -Y-Z direction. The washer could not be identified as flight hardware. The lightning contact strip across the forward part of the LO2 ET/ORB umbilical was missing. Loss of lightning contact strips was the subject of a previous IFA and occurred on STS-57, -58, -65, -66, and -71.

The Solid Rocket Boosters were inspected at Hanger AF after retrieval. The number of MSA-2 debonds over fasteners on the RH frustum (80) and on the LH frustum (63) was greater than average. Hypalon paint was blistered/missing from areas where BTA closeouts had been applied on the frustums, forward skirts, and aft skirts. The HDP Debris Containment System (DCS) plungers were seated and appeared to have functioned properly with the exception of HDP #7. The plunger was not fully seated due to obstruction with the frangible nut.

Orbiter performance as viewed on landing films and videos during final approach, touchdown, and rollout was nominal. Drag chute operation was also normal.

A post landing inspection of OV-105 was conducted 18 September 1995 on SLF runway 33 at the Kennedy Space Center. The Orbiter TPS sustained a total of 198 hits, of which 27 had a major dimension of 1-inch or larger. Based on these numbers and comparison to statistics from previous missions of similar configuration, both the total number of hits and the number of hits 1-inch or larger was greater than average. The Orbiter lower surface sustained a total of 175 hits, of which 22 had a major dimension of 1-inch or larger. Tile damage sites aft of the LH2 ET/ORB umbilical were greater than usual in number and size (116 total with 13 larger than 1-inch). The damage was most likely caused by a combination of impacts from umbilical ice and shredded pieces of umbilical purge barrier material flapping in the airstream.

Tile damage on the window perimeter tiles was concentrated above window #3. The 11 tile damage sites in this area were probably caused by impacts from FRCS paper cover pieces and RTV. A large damage site on a window #5 perimeter tile and two damage sites in the space between windows #3 and #4 were also noted.

The post landing walkdown of Runway 33 was performed immediately after landing. No flight hardware was found on the runway with the exception of a 7-inch long by 1-inch wide Ames gap filler from the nose landing gear door at the Orbiter wheel stop location. All drag chute hardware was recovered and appeared to have functioned normally.

Orbiter post landing microchemical sample results revealed a variety of residuals in the Orbiter window samples from the facility environment, SRB BSM exhaust, Orbiter window polish residue, Orbiter TPS, and paints/primers from various sources. An increase in the concentration of tile repair material in two of the window samples suggests a corresponding increase in tile repair material debris. These residual sampling data do not indicate a single source of damaging debris as all of the noted materials have previously been documented in post-landing sample reports. The residual sample data showed no debris trends when compared to previous mission data.

A total of five Post Launch Anomalies, but no In-Flight Anomalies (IFA's), were observed during the STS-69 mission assessment.

2.0 PRE-LAUNCH BRIEFING

The Debris/Ice/TPS and Photographic Analysis Team briefing for launch activities was conducted on 30 August 1995 at 1000 hours. The following personnel participated in various team activities, assisted in the collection and evaluation of data, and contributed to reports contained in this document.

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S. Otto	LMSO - LSS	ET Processing
M. Barber	LMSO - SPC	Safety

3.0 LAUNCH

STS-69 was launched at 15:09:00.012 GMT (11:09 a.m. local) on 7 September 1995.

3.1 PRE-LAUNCH SSV/PAD DEBRIS INSPECTION

The launch attempt on 31 August 1995 was postponed due to an anomaly in fuel cell #1. The problem was detected prior to cryoload. Replacing the fuel cell caused the launch date to be reset for September 7th.

A pre-launch debris inspection of the launch pad and Shuttle vehicle was performed on 6 September 1995 from 1025 to 1135 hours. The detailed walkdown of Pad 39A and MLP-1 also included the primary flight elements OV-105 Endeavour (9th flight), ET-72 (LWT 65), and BI-074 SRB's. There were no significant vehicle or facility anomalies.

3.2 FINAL INSPECTION

The Final Inspection of the cryoloaded vehicle was performed on 7 September 1995 from 0530 to 0645 hours during the two hour built-in-hold at T-3 hours in the countdown. There were no Launch Commit Criteria (LCC), OMRS, or NSTS-08303 criteria violations. No IPR's were taken. As expected, there was no acreage ice or frost given the ambient weather conditions at this time of year. There were no protuberance icing conditions outside of the established data base.

A portable Shuttle Thermal Imager (STI) infrared scanning radiometer was utilized to scan the vehicle for unusual temperature gradients, particularly those areas not visible from remote fixed scanners, and to obtain a random sampling of vehicle surface temperature measurements to thermally characterize the vehicle.

3.2.1 ORBITER

No Orbiter tile or RCC panel anomalies were observed. The paper covers on RCS thrusters L3D and L4L were intact but tinted green indicating a small internal vapor leak. Typical ice/frost accumulations and condensate were present at the SSME #1 and #2 heat shield-to-nozzle interfaces. An infrared scan revealed no unusual temperature gradients on the base heat shield or engine mounted heat shields.

3.2.2 SOLID ROCKET BOOSTERS

SRB case temperatures measured by the portable STI radiometer ranged from 75 to 77 degrees F. Temperatures measured by the SRB Ground Environment Instrumentation (GEI) ranged from 77-80 degrees F. All measured temperatures were above the 34 degrees F minimum requirement. The predicted Propellant Mean Bulk Temperature (PMBT) supplied by THIO was 81 degrees F, which was within the required range of 44-86 degrees F.

3.2.3 EXTERNAL TANK

The ice/frost prediction computer program 'SURFICE' was run as a general comparison to infrared scanner point measurements. The program predicted condensate with no ice/frost accumulation on the TPS acreage surfaces during cryoload.

The Final Inspection Team observed light condensate, but no ice or frost accumulations, on the LO2 tank. There were no TPS anomalies.

The intertank acreage exhibited no TPS anomalies. Typical ice/frost accumulations, but no unusual vapors, were present on the GUCP. An ice/frost formation, approximately 1-inch in diameter, with venting vapors was located in a stringer valley at the LH2 tank-to-intertank flange closeout bondline just forward of the +Y bipod. The condition was found acceptable for flight.

There were no LH2 tank TPS acreage anomalies. Light condensate, but no ice or frost accumulations, were present on the acreage.

There were no anomalies on the redesigned bipod jack pad closeouts. A crack, 5-inches long by 1/4-inch wide, was present in the -Y ET/SRB cable tray forward surface TPS. The presence of the crack was acceptable for flight per the NSTS-08303 criteria.

Normal amounts of ice/frost had accumulated in the LO2 feedline bellows and support brackets.

There were no TPS anomalies on the LO2 ET/ORB umbilical. Ice/frost fingers on the separation bolt pyrotechnic canister purge vents were typical.

Ice and frost in the LH2 recirculation line bellows and on both burst disks was expected. The LH2 feedline bellows exhibited ice, frost, and condensate.

Typical amounts of ice/frost had accumulated on the LH2 ET/ORB umbilical purge barrier top and outboard sides. Ice/frost fingers were present on the pyro canister and plate gap purge vents. No unusual vapors or cryogenic drips had appeared during tanking, stable replenish, and launch.

The summary of Ice/Frost Team observations/anomalies, which were all acceptable for launch per the NSTS-08303 criteria, consisted of five OTV recorded items.

3.2.4 FACILITY

All SRB sound suppression water troughs were filled and properly configured for launch (LCC requirement).

No leaks were observed on either the LO2 or LH2 Orbiter T-0 umbilicals, the GH2 vent line, or the Ground Umbilical Carrier Plate (GUCP).

Multiple areas of ET nose cone topcoat adhered to both GOX vent seals. One large area, measuring 3-inches long by 1.5 inches wide, was located on the northeast seal.

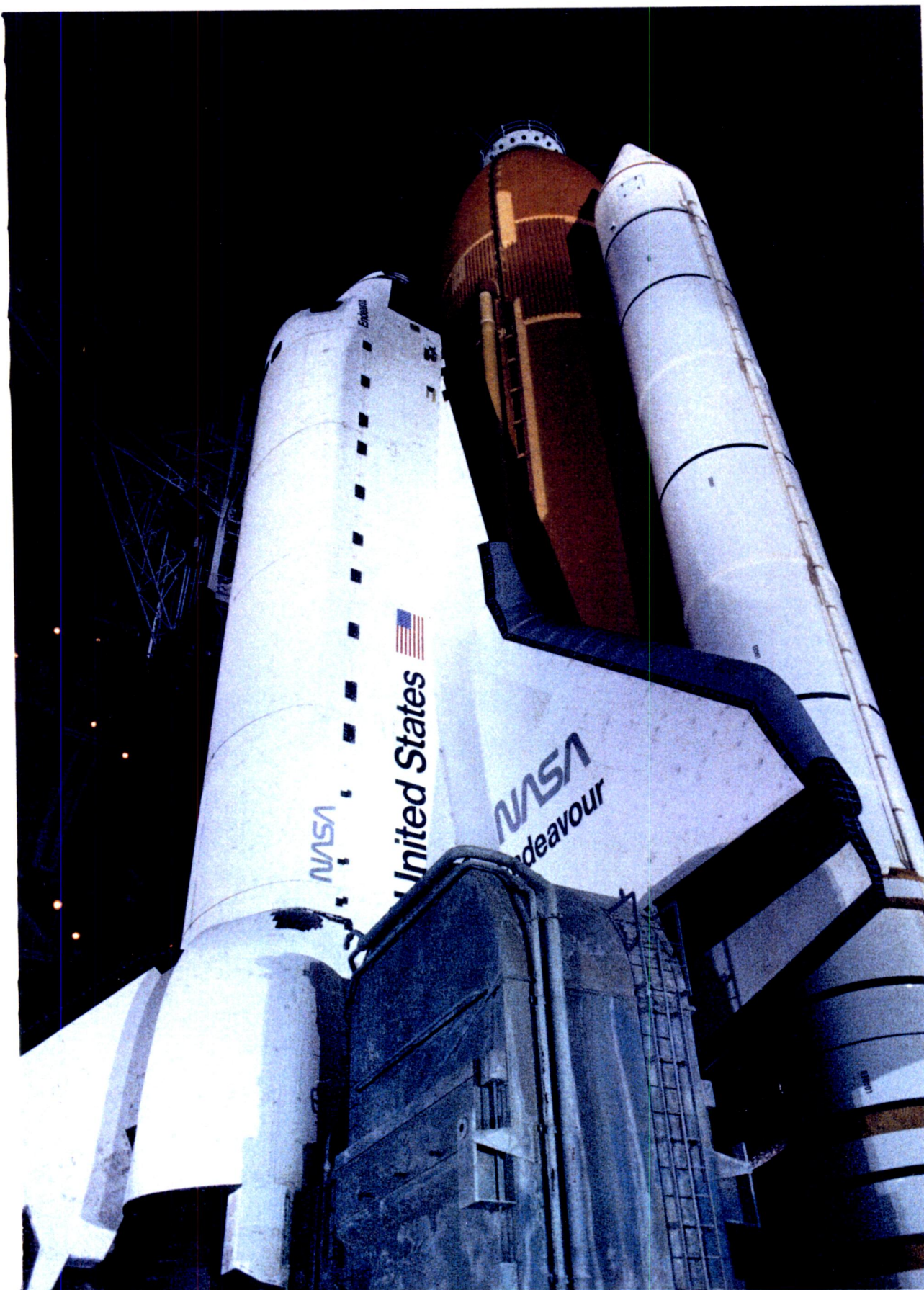


Photo 2 : Vehicle After Cryoload

OV-105 (9th flight), ET-72 (LWT 65), BIO74 SRB's

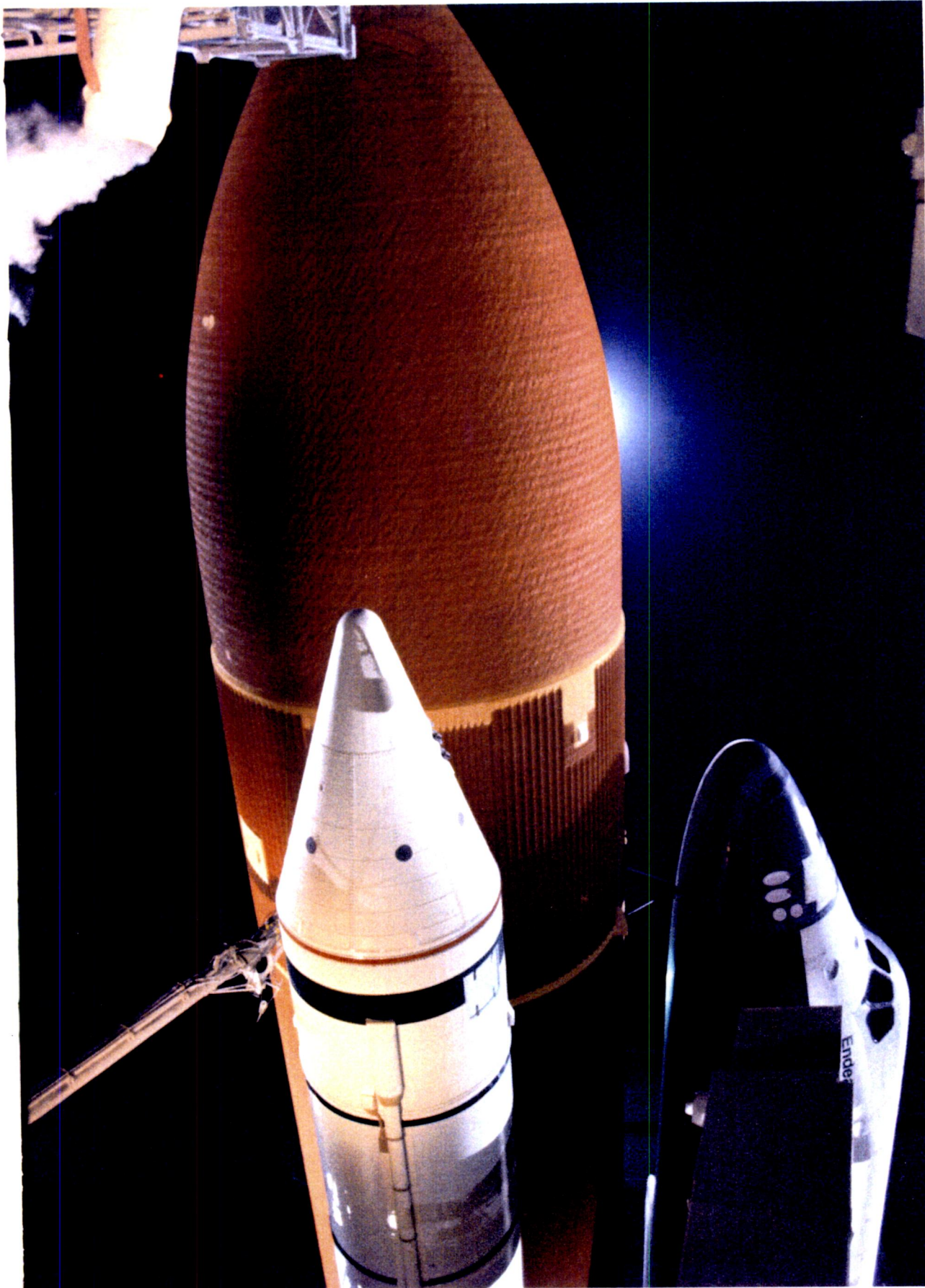


Photo 3 : Cryoloaded External Tank

No acreage ice/frost conditions or TPS anomalies



Photo 4 : LH2 ET/ORB Umbilical

Typical amounts of ice/frost had accumulated on the LH2 ET/ORB umbilical purge barrier top and outboard sides. Ice/frost fingers were present on the pyro canister and plate gap purge vents. No unusual vapors or cryogenic drips had appeared during tanking, stable replenish, and launch.

4.0 POST LAUNCH PAD DEBRIS INSPECTION

The post launch inspection of the MLP, FSS, RSS, and Pad A was conducted on 7 September 1995 from Launch + 1 to 3.5 hours.

No flight hardware or TPS materials were found.

South SRB HDP erosion was typical. All south HDP shoe EPON shim material was intact. There was no visual indication of a stud hang-up on any of the south holddown posts. A 12-inch long by 1/4-inch wide crack was visible at the base of holddown post #3. All of the north HDP doghouse blast covers were in the closed position. Erosion of the blast covers was minimal. Minor damage to the SRB aft skirt purge lines and T-0 umbilicals was similar to previous launches.

The Tail Service Masts (TSM), Orbiter Access Arm (OAA), and GOX vent hood appeared undamaged. Numerous small areas of topcoat from the External Tank nose cone adhered to the lower areas of both +Y and -Y GOX seals. A larger area of topcoat, 3 inches long by 1.5 inches wide, adhered to the northeast seal, but no foam residue from the ET was present. The seals stuck momentarily to the ET nose cone during GOX vent hood retraction at T-2:30 minutes.

The GH2 vent line had no loose cables (static retract lanyard), and appeared to have latched properly with no rebound. However, the retract lanyard had contacted the GUCP leg bracket in four places. The vent line was latched on the eighth tooth of the latching mechanism. The RSS cable had disconnected properly.

Typical pad damage included:

- A lock on the FSS 135 foot level pressure panel box was loose

- A piece of pipe lay on the west pad apron

- A 15 foot long piece of gutter was found near the box cars

Overall, damage to the pad appeared minimal.

Post launch pad inspection anomalies are listed in Section 9.

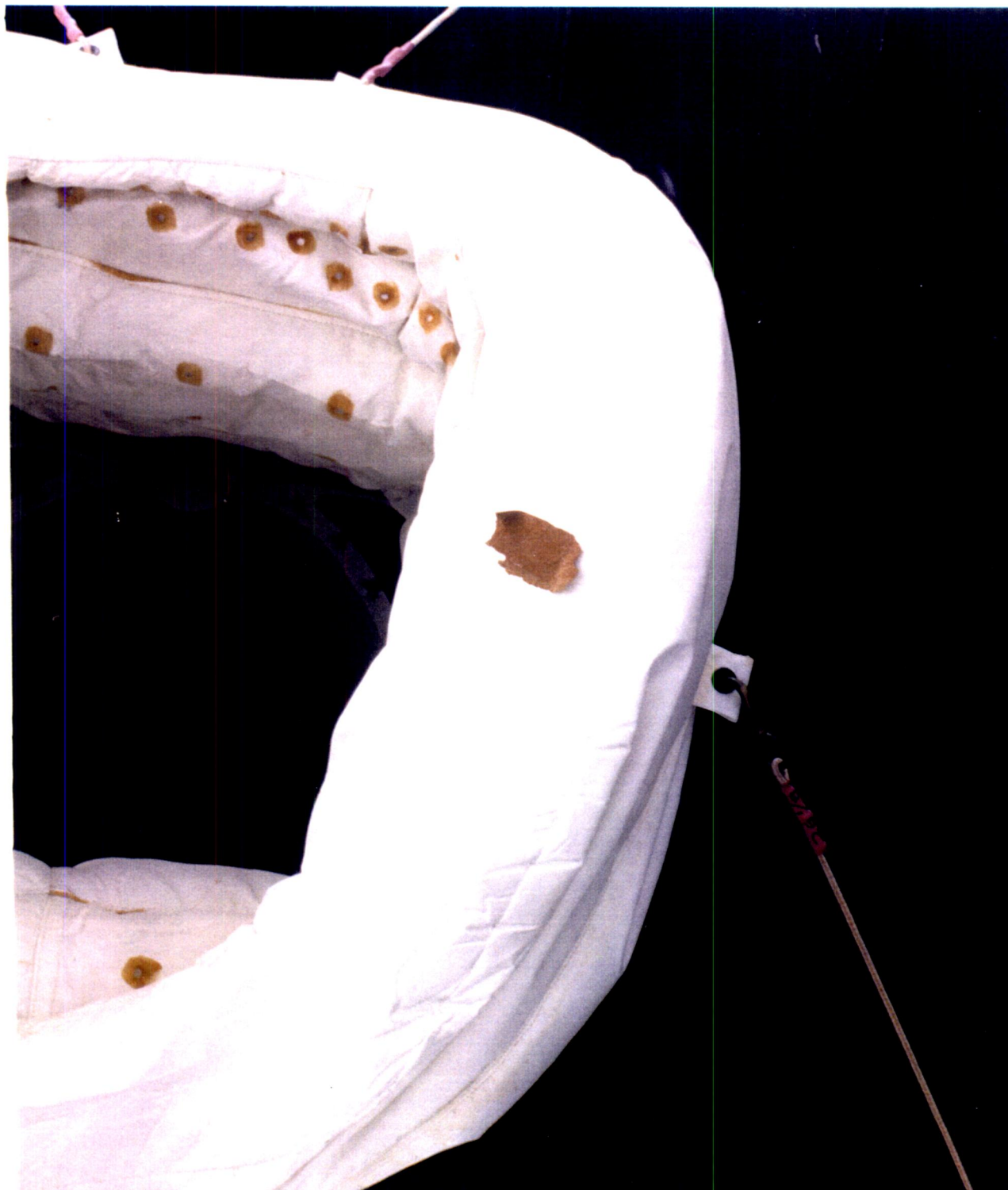


Photo 5 : Nose Cone Topcoat Adhered to GOX Vent Seal

The seals stuck momentarily to the ET nose cone during GOX vent hood retraction at T-2:30 minutes. An area of topcoat, 3 inches long by 1.5 inches wide, adhered to the northeast seal, but no foam residue from the ET was present.

5.0 FILM REVIEW

Anomalies observed in the Film Review were presented to the Mission Management Team, Shuttle managers, and vehicle systems engineers. No IPR's or IFA's were generated as a result of the film review. Post flight anomalies are listed in Section 9.

5.1 LAUNCH FILM AND VIDEO SUMMARY

A total of 100 films and videos, which included thirty-seven 16mm films, twenty 35mm films, four 70mm films, and thirty-nine videos, were reviewed starting on launch day.

Both northeast and southwest GOX vent seals stuck momentarily to the External Tank nosecone topcoat during seal deflation/retraction at T-2:30. Numerous small pieces of topcoat were pulled loose from both footprint areas and adhered to the seals. A larger area of topcoat, 3 inches long by 1.5 inches wide, adhered to the northeast seal, but no foam residue from the ET was present. This condition was acceptable for launch (OTV 013, 060, 061, 062).

Fore-and-aft movement of the Orbiter base heat shield in the centerline area between the SSME cluster occurred during engine start-up. The motion was similar to that observed on previous launches (E-76).

SSME ignition appeared normal (OTV 051, 070, 071). Free burning hydrogen had drifted under the body flap and upward to the base heat shield during start-up (OTV 063, 070, 071). Two flares were visible in the SSME plume during ignition and liftoff (E-3, -5, -62, -77). Another flare occurred in the plume at the start of the roll maneuver 15:09:09.606 GMT (E-52).

Small pieces of tile surface coating material were lost from 3 places on the base heat shield outboard of SSME #3 (E-17), 2 places outboard of SSME #2 (OTV 050), and 2 places on the base heat shield near the SSME's (E-19, -20).

Water, or condensate, fell from the ET +Y vertical strut drain hole during SSME ignition (OTV 054).

The Orbiter LH2 and LO2 T-0 umbilicals disconnected and retracted properly (OTV 049, 050).

GUCP disconnect from the ET was nominal. No foam was torn loose during retraction. During liftoff, ice shook loose from the GUCP and continued to fall along side the LH SRB (E-33, OTV 004). GH2 vent line retraction and latch were normal (E-41, -50, -60).

A dark object appeared behind the SSME #2 and #3 nozzles at 0.9 seconds MET (15:09:00.883 GMT) and fell aft into the SSME plume. The object was originally thought to be a piece of a body flap stub tile from the body flap hinge area (E-19, -76, -77). However, post landing inspection of the Orbiter revealed no missing stub tile pieces. The object was probably a tile gap filler.

No stud hang-ups occurred on any of the holddown posts. No ordnance fragments or frangible nut pieces fell from any of the DCS/stud holes (E-7 thru E-14).

Debris particles, most likely pieces of SRB throat plug material, were ejected out of the RH SRB exhaust hole, passed by the RH SRB aft skirt, and moved away from the vehicle shortly after T-0 (E-1). A dark, thin, 2 inch square object was ejected upward out of the LH SRB exhaust hole in the direction of the FSS (E-4). A small object, which is not believed to be tile surface coating material, appeared from an area behind the LO2 TSM and passed by the +Y edge of the body flap without contacting the vehicle (E-6).

A considerable amount of thin deck scale and debris moved around the MLP deck at T-0. One large gray piece estimated to be 3 inches long fell into the SRB exhaust hole near HDP #4 (E-7). At least eight pieces of SRB throat plug material were ejected out of the SRB exhaust hole past HDP #7 after the blast cover closed (E-11).

Several leaks in sound suppression water pipe joints were noted (E-11, -14, -15, -16).

White puffs of smoke were visible near the RH SRB aft skirt shortly after liftoff and were caused by HPU exhaust. Pieces of SRB throat plug material and ice from the cryogenic cross country lines appeared above the north flame trench (E-222).

A large, light-colored flexible object ejected out of the SRB exhaust hole northwest of the vehicle 1.6 seconds after T-0 is believed to be a piece of the plastic liner inside the orange sound suppression water troughs (E-62, -77).

At 2.2 seconds MET, an unidentified white object appeared near the LH SRB aft skirt aft ring/HDP #6 area during liftoff. The object was moving away from the vehicle, but the origin could not be determined from this field of view (E-76). A small, bright white object originated from the SRB exhaust hole and moved northward away from the vehicle. This object is believed to be the unidentified white object observed in film item E-76. However, this view confirmed the white object was not flight hardware, but more likely SRB throat plug material (E-62).

Two pieces of ice were shaken loose after liftoff from the EB-7 fitting, but no impacts to flight hardware were observed (E-57).

Movement of the GOX vent hood in the SRB plume after the vehicle cleared the tower appeared to be less than usual. However, in-and-out movement of the vent door on the south side of the hammerhead crane was more indicative of SRB plume effects (E-62).

A bird appearing under the right inboard elevon at 15:09:04.973 and disappearing behind the LH SRB aft skirt was east of the pad surface and not near the vehicle (E-57, 59).

Localized flow condensation collars formed on various parts of the vehicle during ascent as expected given the warm, humid atmospheric conditions for this launch (TV-5; E-207, -208, -213, -220, -222, -224).

Body flap movement (amplitude and frequency) appeared similar to previous flights (E-213).

A flash occurred in the SSME plume during ascent at 32 seconds MET (E-220, -222).

Exhaust plume recirculation, ET aft dome charring, and SRB separation appeared nominal (TV-13, E-212).

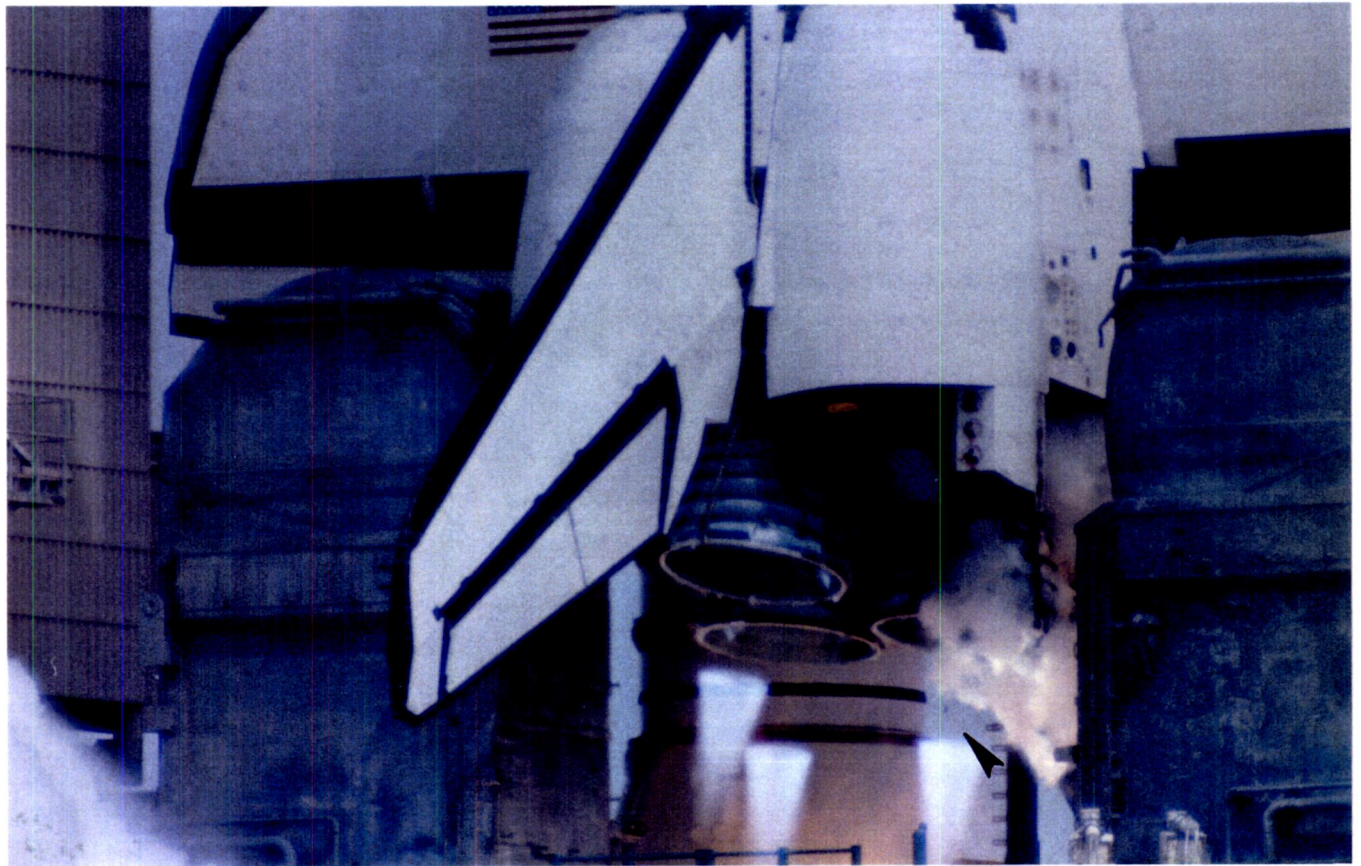


Photo 6 : Debris Prior to Liftoff

A dark object appeared behind the SSME #2 and #3 nozzles at 0.9 seconds MET (15:09:00.883 GMT) and fell aft into the SSME plume. Post landing inspection of the Orbiter revealed no missing body flap stub tiles pieces. The object is believed to be a tile gap filler.

5.2 ON-ORBIT FILM AND VIDEO SUMMARY

OV-105 was equipped to carry umbilical cameras: 16mm motion picture with 5 mm lens; 16mm motion picture with 10mm lens; 35mm still views. Data was obtained from all three cameras. Hand held photography by the flight crew was omitted for this mission.

No vehicle damage or lost flight hardware was observed that would have been a safety of flight concern.

SRB separation from the External Tank was nominal. More than usual, but small, pieces of foam fell past the camera lens.

ET-72 separation from the Orbiter was nominal. The BSM burn scars on the LO2 tank were typical. No anomalies were observed on the nosecone, PAL ramps, LO2 feed line, and aft dome.

A thin, metallic, 1/2-inch diameter washer originated from an area behind the LH2 ET/ORB umbilical cable tray after umbilical separation (5mm film, frame 4230) and drifted generally in the -Y-Z direction. The washer could not be identified as flight hardware.

No divots were observed on the intertank acreage nor on the LH2 tank-to-intertank flange closeout. Light colored spot on the intertank near the -Y bipod spindle housing closeout was an area sanded prior to launch.

Both new-method bipod jack pad closeouts appeared to be intact.

The LH2 tank acreage was generally in good condition. Numerous shallow "popcorn" type divots occurred forward of the crossbeam on the aft barrel section.

LO2 feedline flange closeouts, both thrust strut flange closeouts, and the TPS on several pressurization line supports exhibited minor erosion. Ice was still present in the LO2 feedline lower bellows.

The LH2 ET/ORB umbilical appeared to be in good condition with little or no TPS damage. Foam was missing or eroded from the horizontal (clamshell) section of the cable tray and the aft surface of the -Y vertical strut.

The LO2 ET/ORB umbilical sustained minor TPS damage on the forward surface. Numerous divots and eroded areas were visible on the horizontal and vertical sections of the cable tray. The lightning contact strip across the forward part of the umbilical was missing. Loss of lightning contact strips was the subject of a previous IFA and occurred on STS-57, -58, -65, -66, and -71.

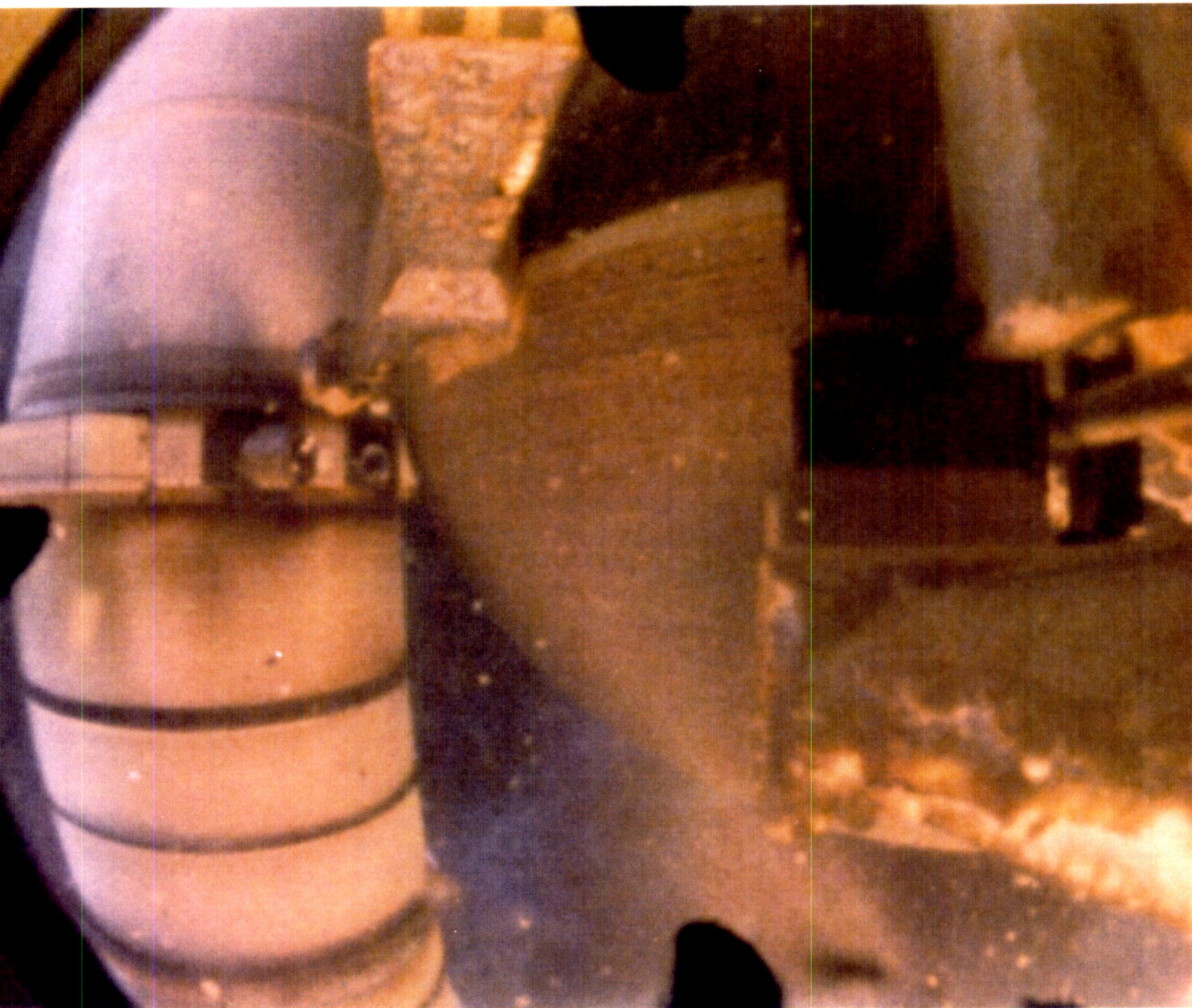


Photo 7 : SRB Separation from External Tank

SRB separation from the External Tank was nominal. More than usual, but small, pieces of foam fell past the camera lens. Charring/erosion of foam on the aft surfaces of the -Y vertical strut and LH2 ET/ORB umbilical cable tray was typical.



Photo 8 : Loose Metallic Washer

A thin, metallic, 1/2-inch diameter washer (arrow) originated from an area behind the LH2 ET/ORB umbilical cable tray after umbilical separation (5mm film, frame 4230) and drifted generally in the -Y-Z direction. The washer could not be identified as flight hardware.

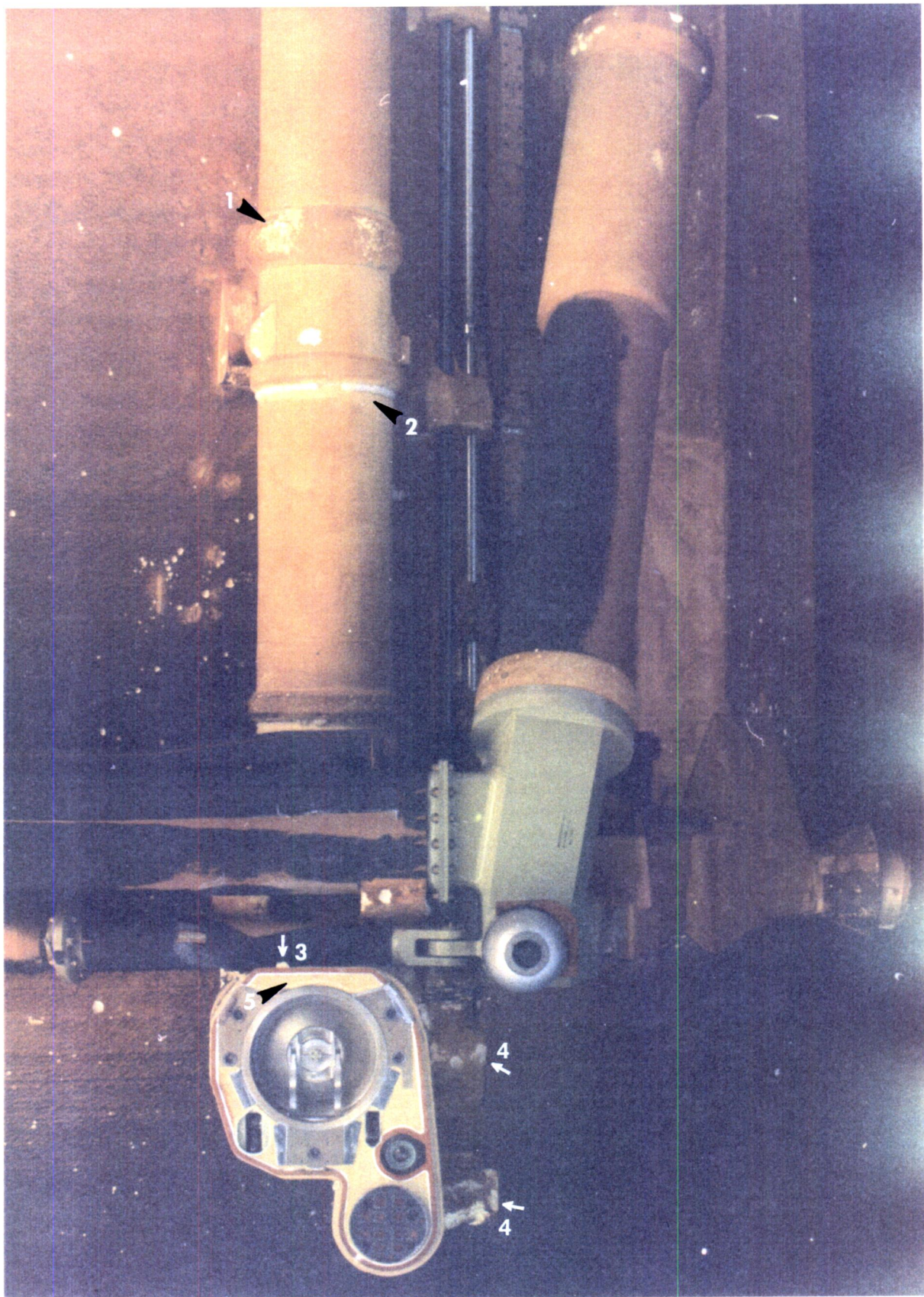


Photo 9 : LO2 ET/ORB Umbilical

The LO2 feedline flange TPS closeout exhibited minor erosion (1). Ice was still present in the feedline lower bellows (2). The LO2 ET/ORB umbilical sustained minor TPS damage on the forward surface (3). Numerous divots and eroded areas were visible on the horizontal and vertical sections of the cable tray (4). The lightning contact strip across the forward part of the umbilical was missing (5).

5.3 LANDING FILM AND VIDEO SUMMARY

A total of 19 films and videos, which included two 16mm high speed films, seven 35mm large format films and ten videos, were reviewed.

Orbiter performance in the Heading Alignment Circle (HAC) and final approach appeared nominal. Wing tip vortices on final approach were visible due to the amount of moisture in the air at the time of landing.

The landing gear extended properly. The infrared scanners showed no debris falling from the Orbiter during final approach. Left and right main landing gear touchdown was almost simultaneous. The Orbiter touched down east of the runway centerline with the LH MLG tire on the runway centerline stripe.

Drag chute deployment appeared nominal.

Touchdown of the nose landing gear was smooth. The Orbiter was steered westward until the nose landing gear straddled the runway centerline.

No significant TPS damage was visible during rollout with the exception of tile damage site on the RH main landing gear door. Rollout and wheel stop were uneventful.

A large format 35mm camera was positioned in line with the runway threshold line to determine the altitude of the Orbiter crossing the runway threshold using photographic means. That value would then be compared at JSC to the Orbiter on-board instrumentation. Measurements on the film were taken when the left main landing gear tire was centered over the 10 foot wide threshold line at GMT 11:37:49.768. An altitude of 16.4 feet from the lowest point on the left main gear tire to the runway surface was calculated.

6.0 SRB POST FLIGHT/RETRIEVAL DEBRIS ASSESSMENT

The BI-074 Solid Rocket Boosters were inspected for debris damage and debris sources at CCAS Hangar AF on 8-9 September 1995. From a debris standpoint, both SRB's were in good condition.

6.1 RH SOLID ROCKET BOOSTER DEBRIS INSPECTION

The RH frustum was missing no TPS. The number of debonds (80) over fasteners was greater than average (Figure 1). Hypalon paint was blistered/missing along the XB-395 ring frame where BTA closeouts had been applied. Some of the underlying BTA was sooted. The BSM aero heat shield covers had locked in the fully opened position.

The RH forward skirt exhibited no debonds or missing TPS. Both RSS antennae covers/phenolic base plates were intact. Hypalon paint was blistered/missing over the areas where BTA closeouts had been applied. No pins were missing from the frustum severance ring.

The Field Joint Protection System (FJPS) closeouts were generally in good condition. Trailing edge damage to the FJPS and the GEI cork runs were attributed to debris resulting from severance of the nozzle extension.

Separation of the aft ET/SRB struts appeared normal. No K5NA was missing from the separation plane of the upper strut fairing. The ETA ring, IEA, and IEA covers appeared undamaged. The aft booster stiffener ring splice plate closeouts were intact and no K5NA material was missing. Aft skirt MSA-2 was intact.

The HDP Debris Containment System (DCS) plungers appeared to have functioned properly though small pieces of debris were visible wedged against the HDP #1 and #2 plungers.

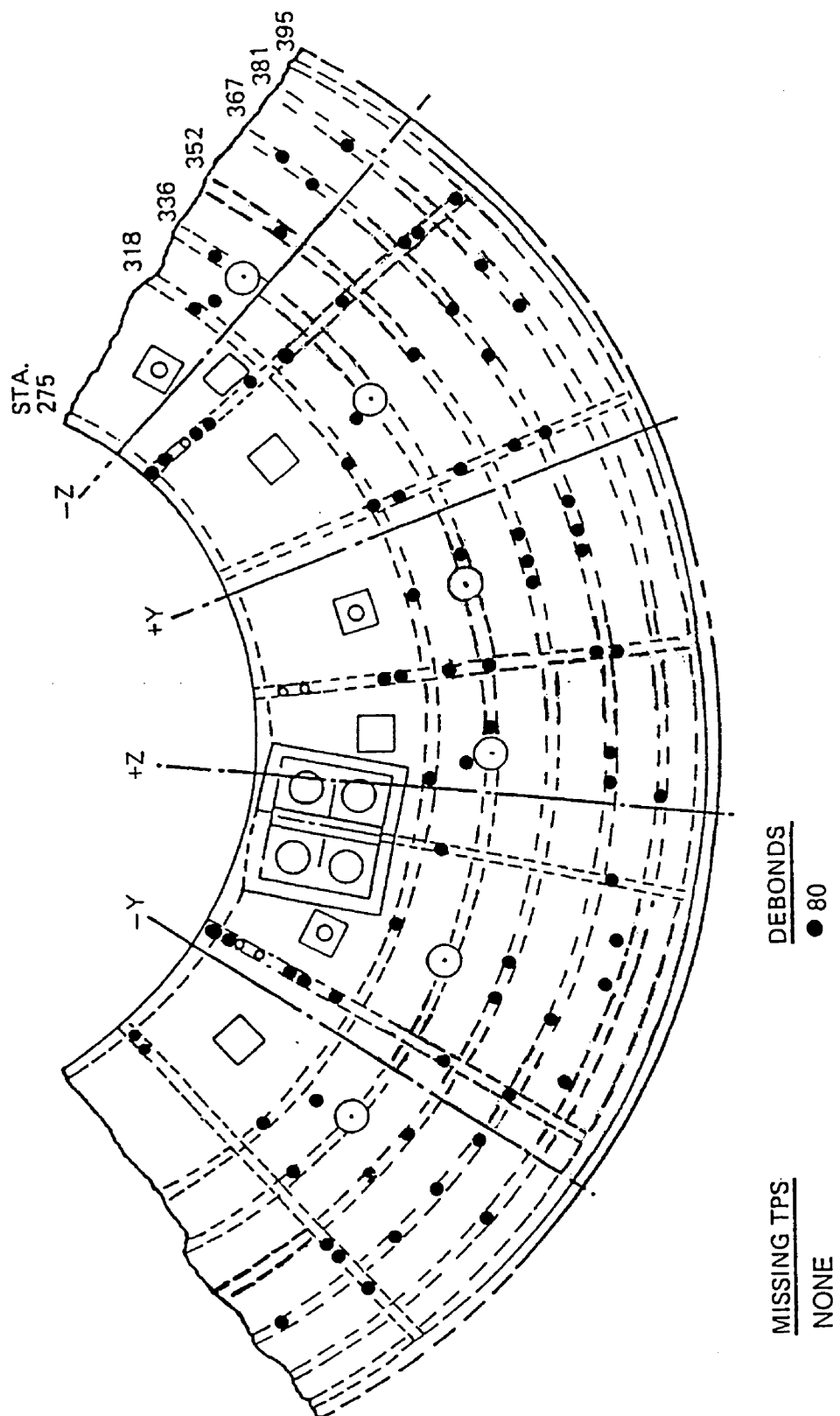


Figure 1 : RH SRB Frustum

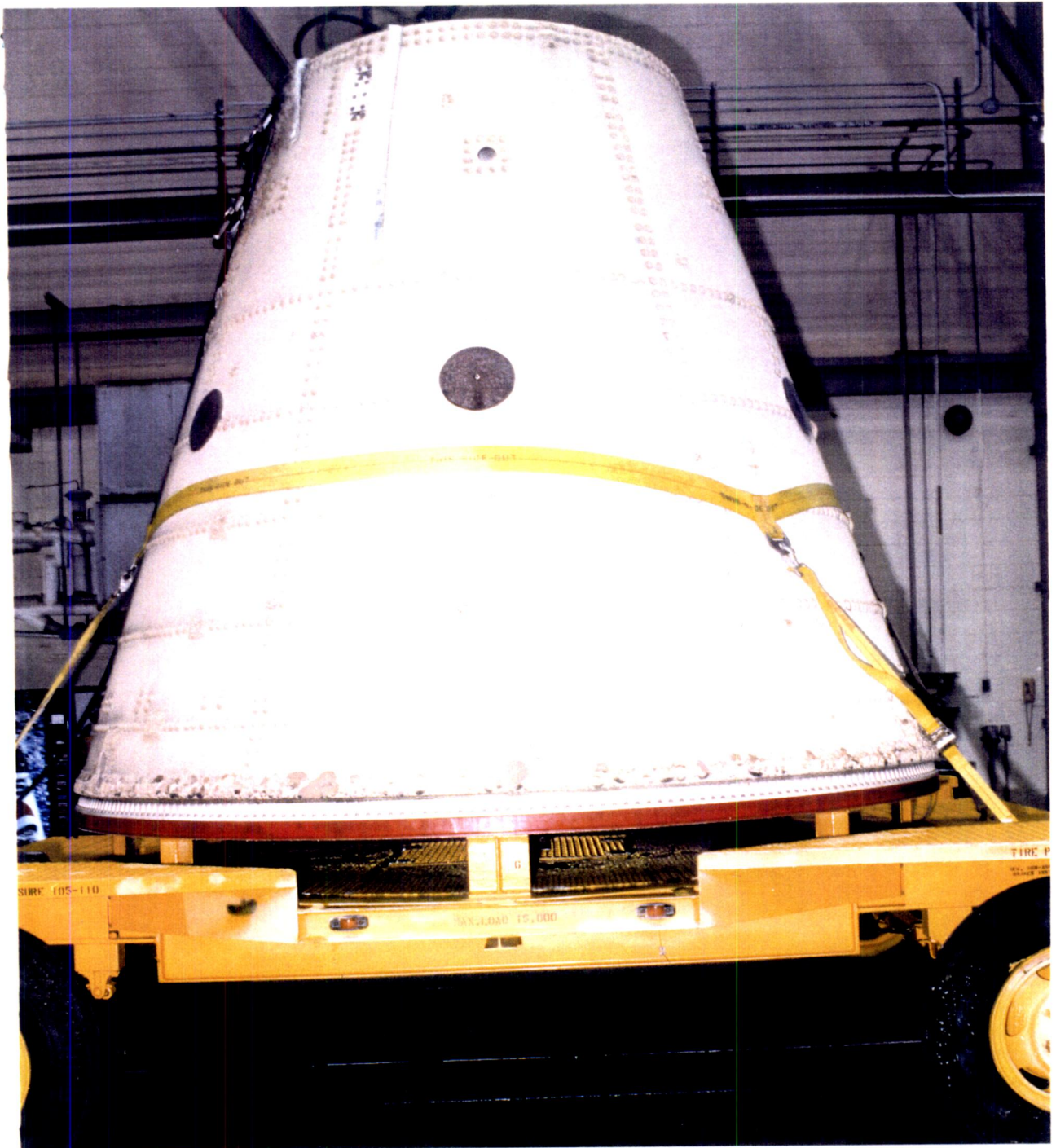


Photo 10 : RH Frustum

The RH frustum was missing no TPS. The number of debonds (80) over fasteners was greater than average. Hypalon paint was blistered/missing along the XB-395 ring frame where BTA closeouts had been applied. Some of the underlying BTA was sooted.

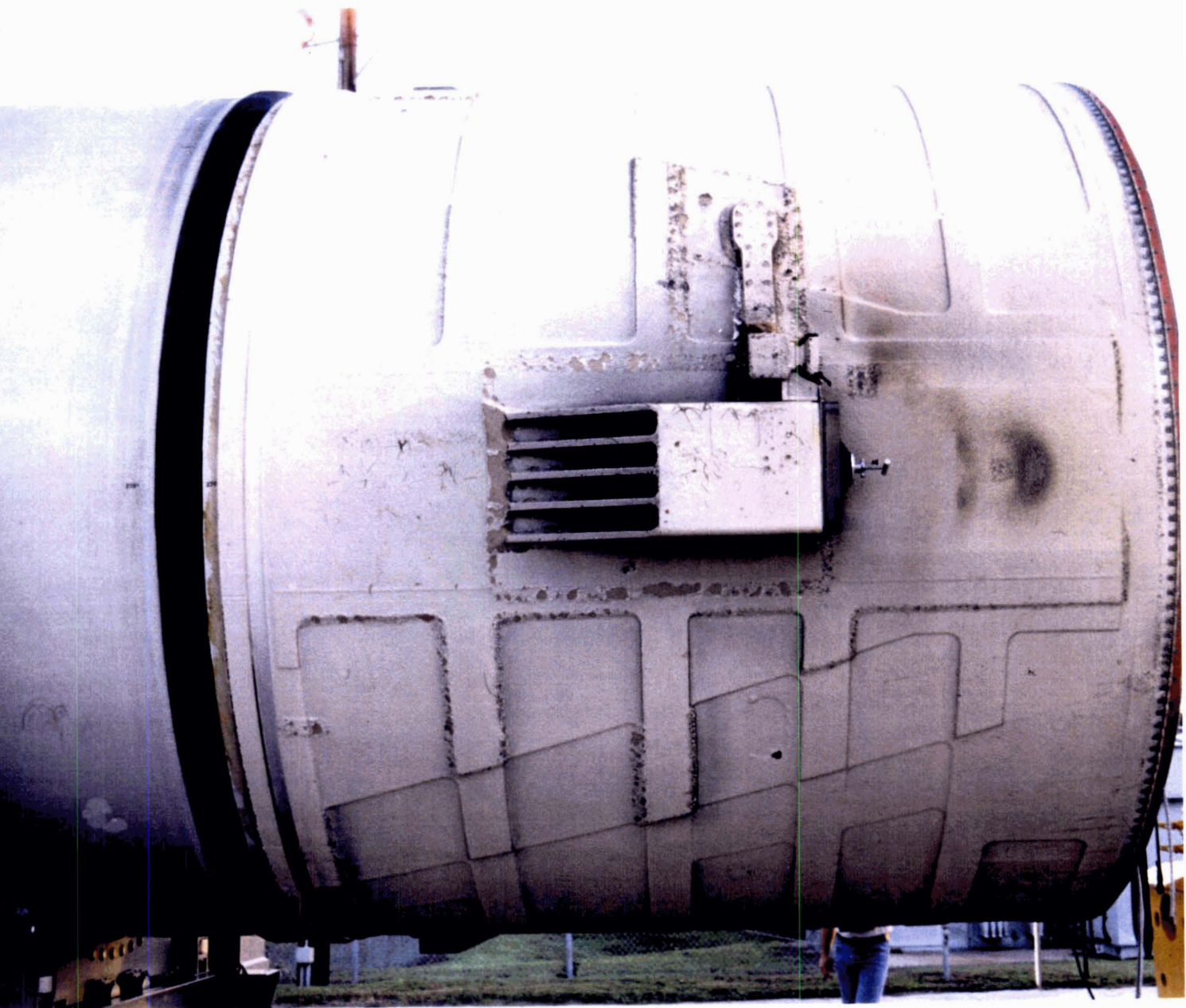


Photo 11 : RH Forward Skirt



Photo 12 : RH Aft Booster/ Aft Skirt

6.2 LH SOLID ROCKET BOOSTER DEBRIS INSPECTION

The LH frustum was missing no TPS. The number of MSA-2 debonds (63) over fasteners was greater than average (Figure 2). Hypalon paint was blistered/missing along the XB-395 ring frame where BTA closeouts had been applied. Some of the underlying BTA was sooted. The BSM aero heat shield covers had locked in the fully opened position.

The LH forward skirt exhibited no debonds or missing TPS. Both RSS antennae covers/phenolic base plates were intact. Hypalon paint was blistered/missing over the areas where BTA closeouts had been applied. No pins were missing from the frustum severance ring.

The Field Joint Protection System (FJPS) closeouts were in good condition. In general, minor trailing edge damage to the FJPS and the GEI cork runs were attributed to debris resulting from severance of the nozzle extension.

Separation of the aft ET/SRB struts appeared normal. No K5NA was missing from the separation plane of the upper strut fairing. The ETA ring, IEA, and IEA covers appeared undamaged. The stiffener ring splice plate closeouts were intact and no K5NA material was missing. Aft skirt MSA-2 was intact.

The HDP Debris Containment System (DCS) plungers were seated and appeared to have functioned properly with the exception of HDP #7. The plunger was not fully seated due to obstruction with the frangible nut.

SRB Post Launch Anomalies are listed in Section 9.

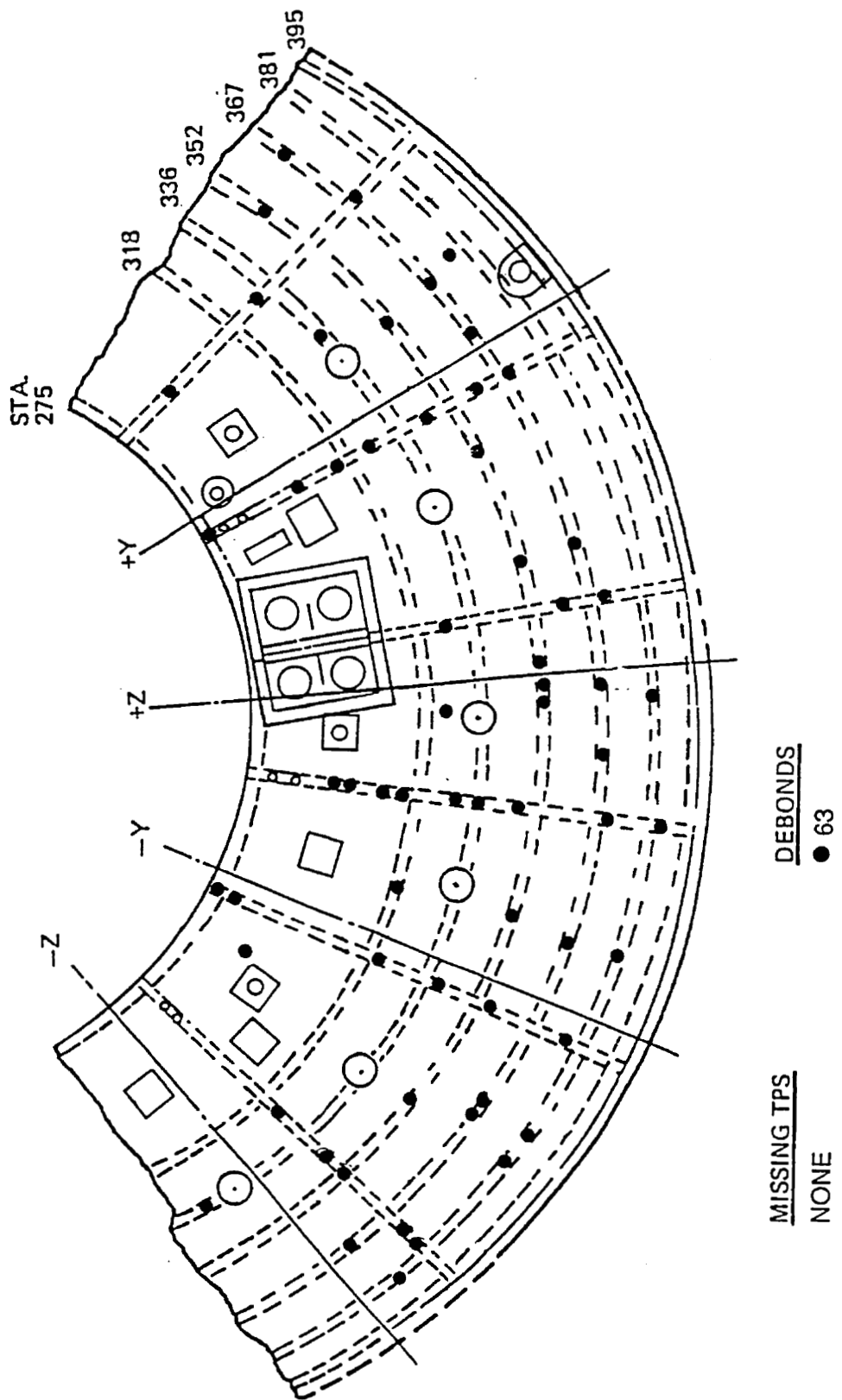


Figure 2 : LH SRB Frustum

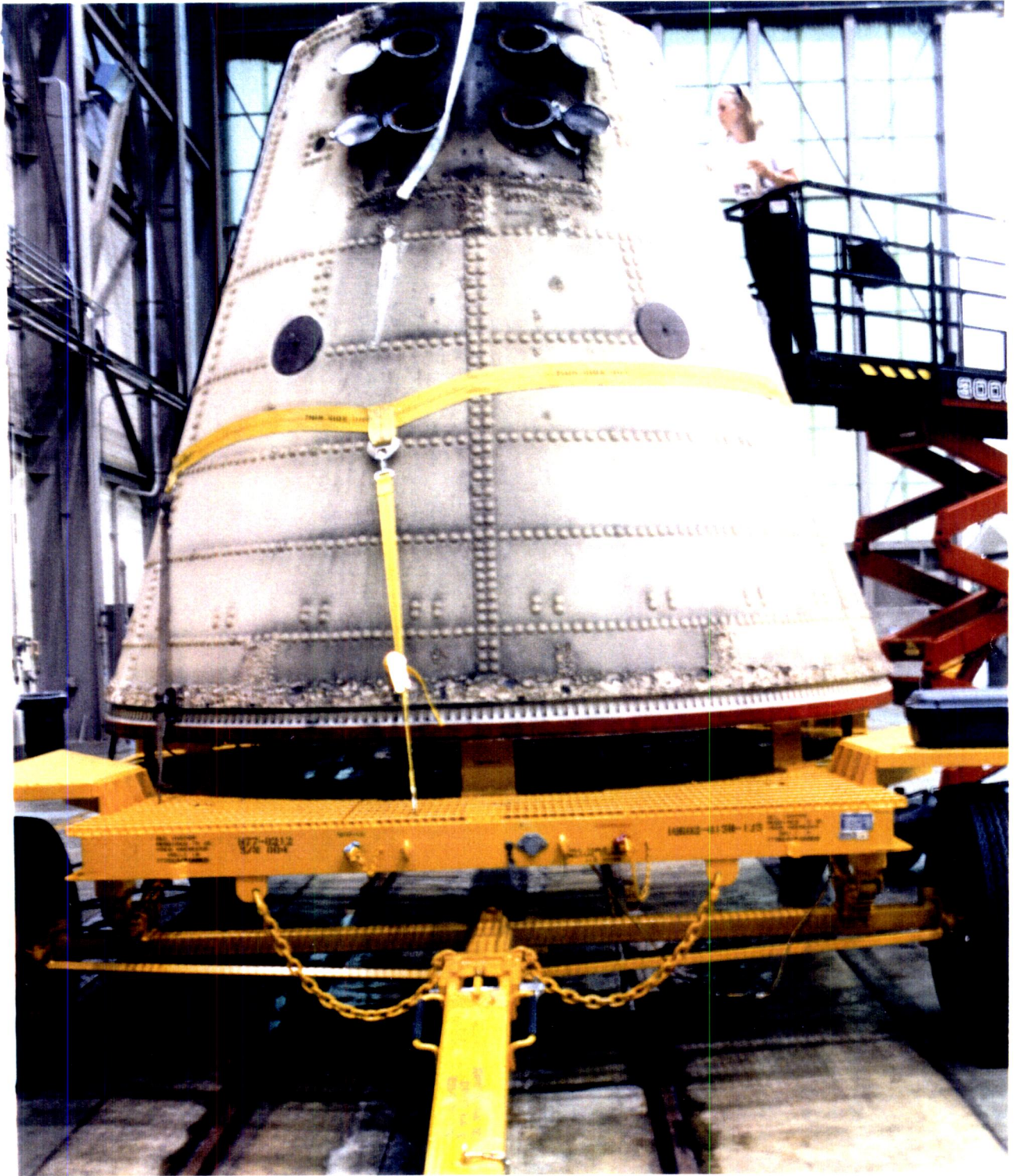


Photo 13 : LH Frustum

The LH frustum was missing no TPS. The number of MSA-2 debonds (63) over fasteners was greater than average. Hypalon paint was blistered/missing along the XB-395 ring frame where BTA closeouts had been applied. Some of the underlying BTA was sooted.

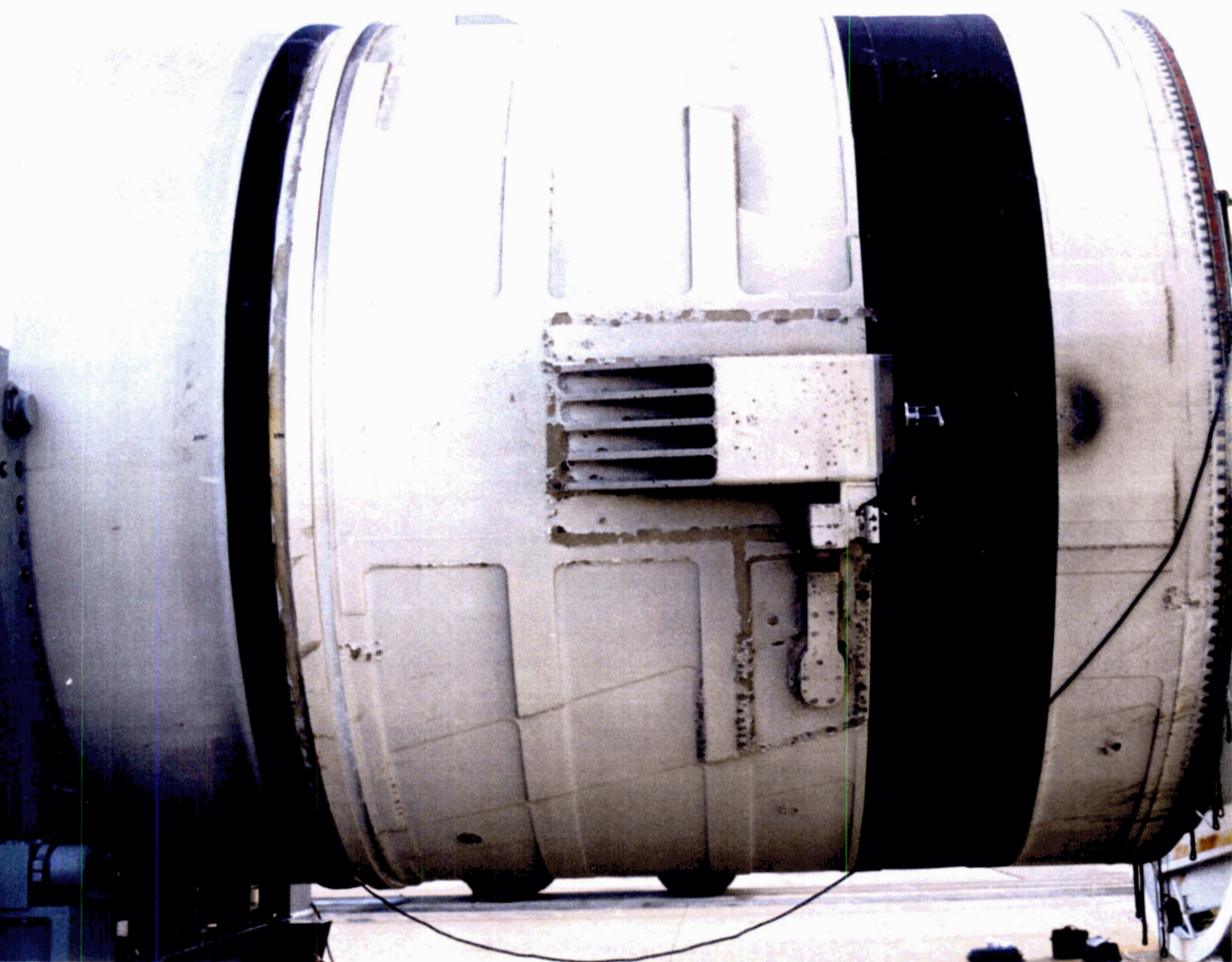


Photo 14 : LH Forward Skirt



Photo 15 : LH Aft Booster/ Aft Skirt

7.0 ORBITER POST LANDING DEBRIS ASSESSMENT

A post landing debris inspection of OV-105 Endeavour was conducted 18-19 September 1995 at the Kennedy Space Center on SLF runway 33 and in the Orbiter Processing Facility bay #3. This inspection was performed to identify debris impact damage and, if possible, debris sources. The Orbiter TPS sustained a total of 198 hits, of which 27 had a major dimension of 1-inch or larger. This total does not include the numerous hits on the base heat shield attributed to SSME vibration/acoustics and exhaust plume recirculation. A comparison of these numbers to statistics from 55 previous missions of similar configuration (excluding missions STS-23, 25, 26, 26R, 27R, 30R, and 42, which had damage from known debris sources), indicates both the total number of hits and the number of hits 1-inch or larger was greater than average (Reference Figures 3-6).

The following table breaks down the STS-69 Orbiter debris damage by area:

	<u>HITS > 1"</u>	<u>TOTAL HITS</u>
Lower surface	22	175
Upper surface	3	16
Right side	0	1
Left side	0	0
Right OMS Pod	1	3
Left OMS Pod	1	3
TOTALS	27	198

Tile damage sites aft of the LH2 ET/ORB umbilical were greater than usual in number and size (116 total with 13 larger than 1-inch). The damage was most likely caused by a combination of impacts from umbilical ice and shredded pieces of umbilical purge barrier material flapping in the airstream.

Many tile damage sites were located to the right of centerline on the lower surface. Hits in this area along a line from nose to tail are generally attributed to ice impacts from the ET LO2 feedline bellows and support brackets.

No tile damage from micrometeorites or on-orbit debris was identified during the inspection.

The tires and brakes were reported to be in good condition for a landing on the KSC concrete runway.

ET/Orbiter separation devices EO-1, EO-2, and EO-3 functioned normally. All ET/Orbiter umbilical separation ordnance retention shutters were closed properly. Small amounts of umbilical closeout foam and white RTV dam material adhered to the umbilical plate near the LH2 recirculation line disconnect. No debris was found on the runway beneath the ET/ORB umbilicals.

All three Dome Mounted Heat Shield (DMHS) closeout blankets were in excellent condition with no tears or missing material. Tiles on the vertical stabilizer "stinger" and around the drag chute door were intact and undamaged.

A piece of tile, 2.25-inches long by 2-inches wide by 5/8-inch thick was loose on the base heat shield outboard of SSME #2. The filler bar was exposed when the loose piece was removed.

No body flap hinge stub (piano key) tiles were missing or damaged. Surface coating material, 5-inches long by 1-inch wide, was missing from an area spanning two tiles on the upper (+Z) side of the body flap at the hinge line between SSME #2 and #3. However, the coating was too thin to be the object observed in the post launch film review falling from this area after SSME ignition. The object in the films is now believed to be a 6-inch long by 2-inch wide gap filler from this same general area.

No ice adhered to the payload bay door. A white residue was observed around the waste water dump nozzles. No unusual tile damage was observed on the leading edges of the OMS pods. However, two small tile damage sites were visible from ground level on the leading edge of the vertical stabilizer.

Orbiter windows #3 and #4 exhibited moderate hazing and streaking. A light haze was present on the other windows. Tile damage on the window perimeter tiles was concentrated above window #3. The 11 tile damage sites in this area were probably caused by impacts from FRCS paper cover pieces and RTV. A large damage site on a window #5 perimeter tile and two damage sites in the space between windows #3 and #4 were also noted.

The post landing walkdown of Runway 33 was performed immediately after landing. No flight hardware was found on the runway with the exception of a 7-inch long by 1-inch wide Ames gap filler from the nose landing gear door at the Orbiter wheel stop location. All drag chute hardware was recovered and appeared to have functioned normally.

In summary, both the total number of Orbiter TPS debris hits and the number of hits 1-inch or larger was greater than average when compared to previous missions (Figure 7).

Orbiter Post Launch Debris Anomalies are listed in Section 9.

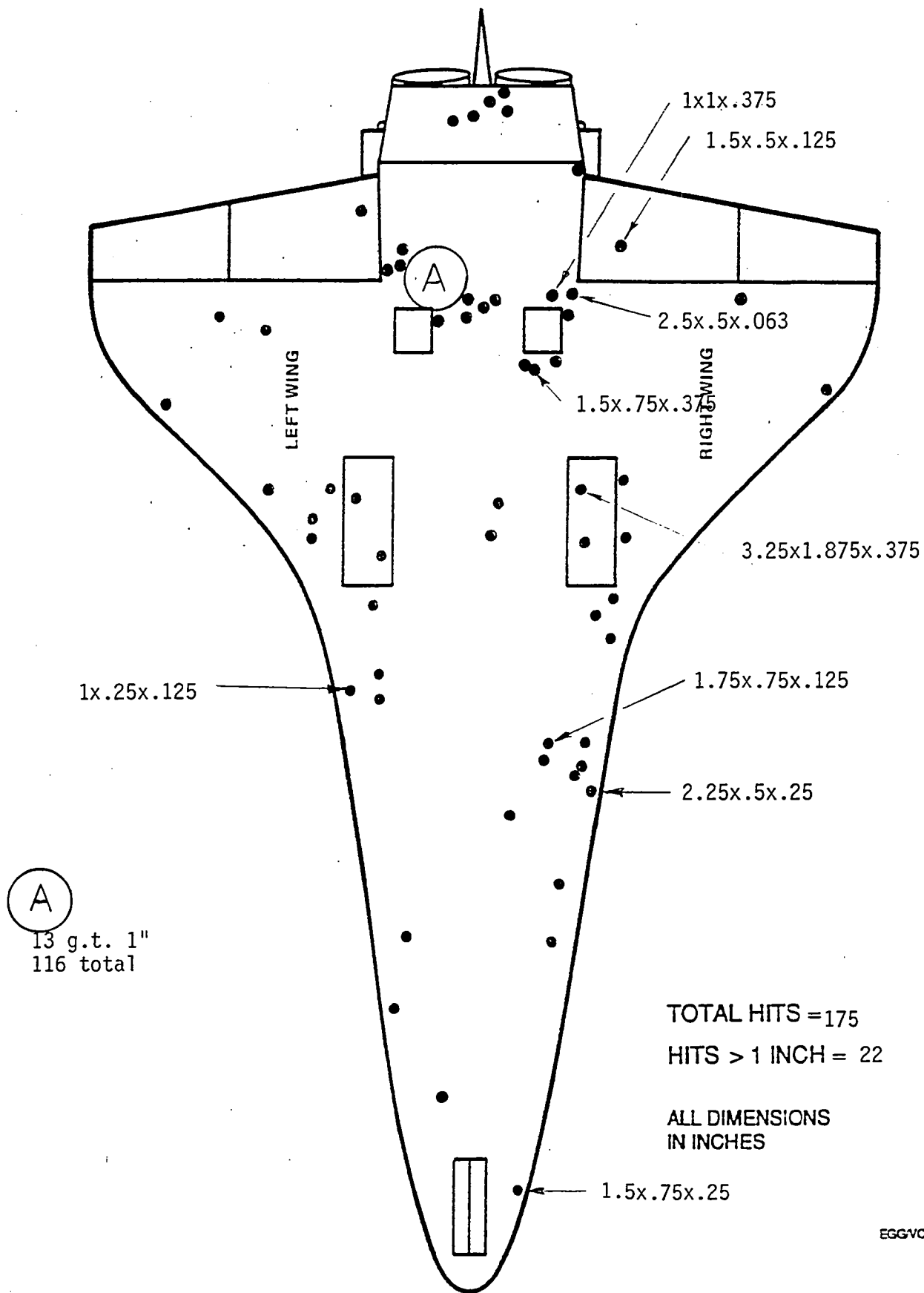
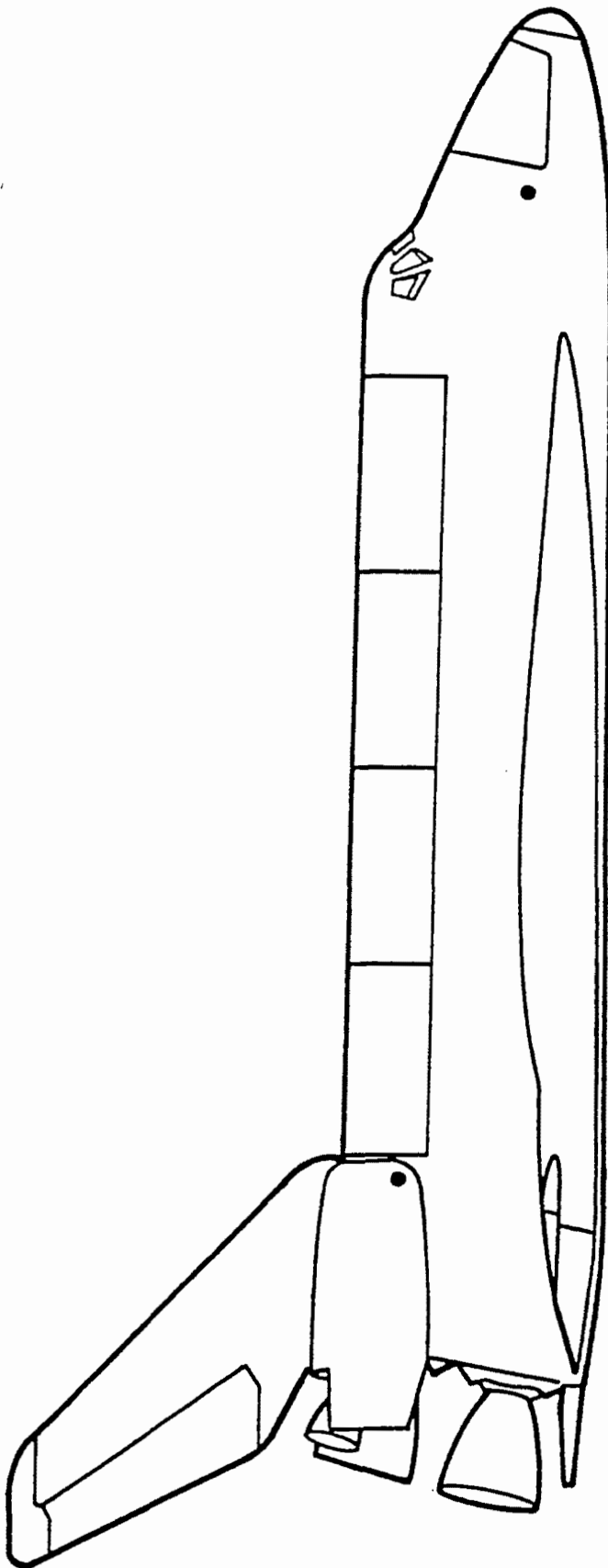
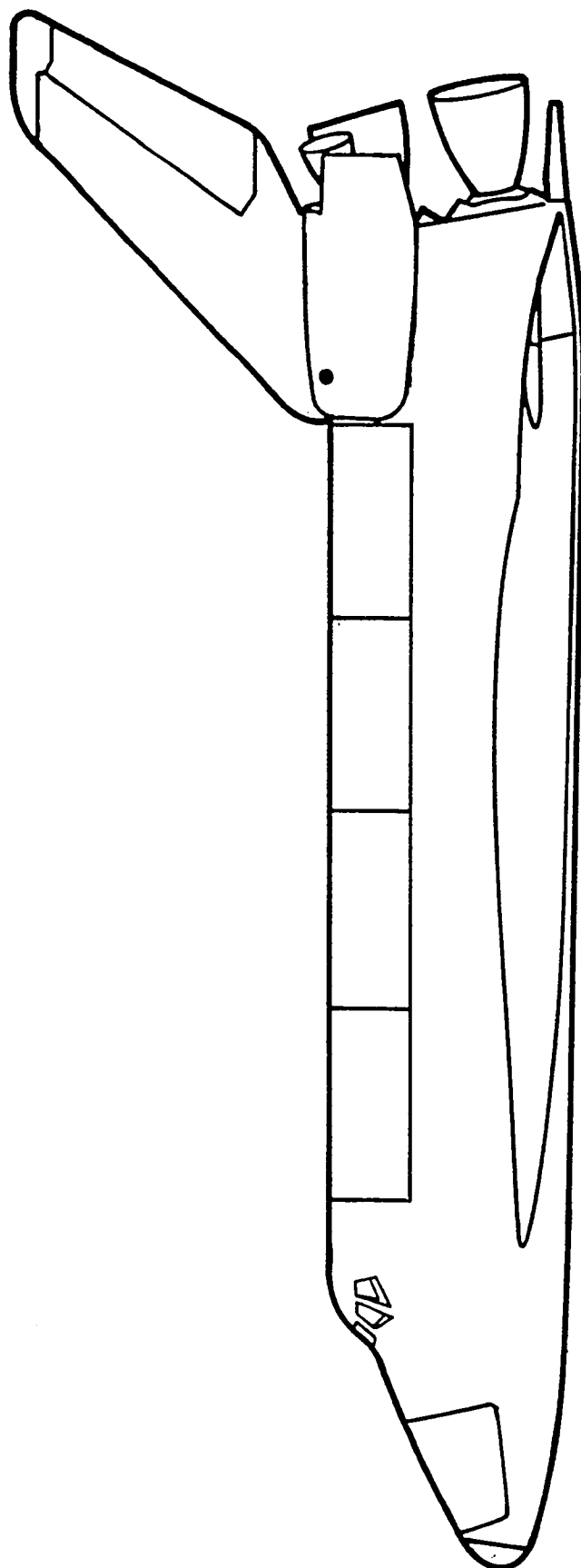


Figure 3 : Orbiter Lower Surface Debris Map



TOTAL HITS = 2
HITS \geq 1 INCH = 0

Figure 4 : Orbiter Right Side Debris Map



TOTAL HITS = 1
HITS \geq 1 INCH = 0

EGG/V-088

Figure 5 : Orbiter Left Side Debris Map

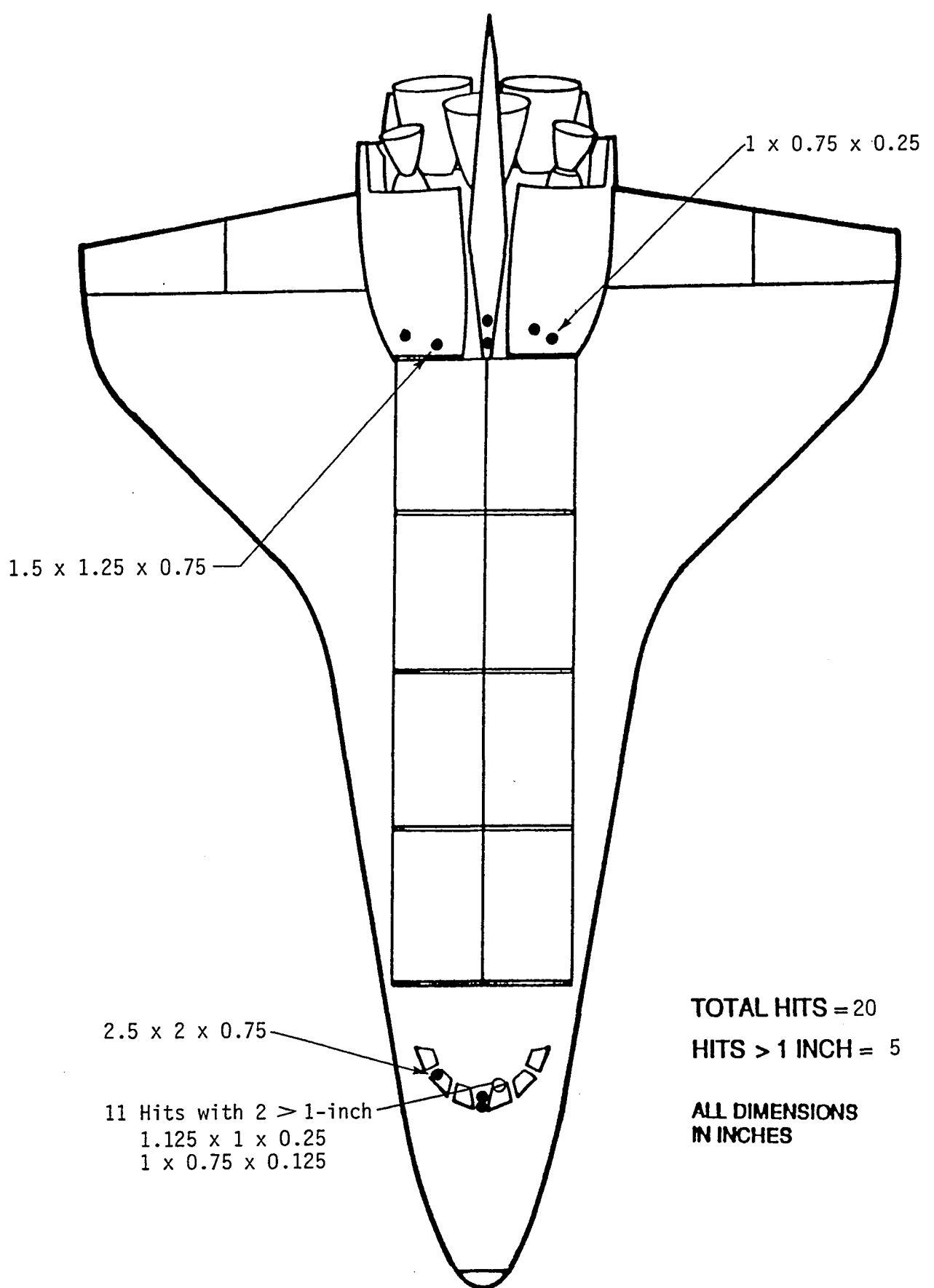


Figure 6 : Orbiter Upper Surface Debris Map

	LOWER SURFACE		ENTIRE VEHICLE	
	HITS > 1 INCH	TOTAL HITS	HITS > 1 INCH	TOTAL HITS
STS-6	15	80	36	120
STS-8	3	29	7	56
STS-9 (41-A)	9	49	14	58
STS-11 (41-B)	11	19	34	63
STS-13 (41-C)	5	27	8	36
STS-14 (41-D)	10	44	30	111
STS-17 (41-G)	25	69	36	154
STS-19 (51-A)	14	66	20	87
STS-20 (51-C)	24	67	28	81
STS-27 (51-I)	21	96	33	141
STS-28 (51-J)	7	66	17	111
STS-30 (61-A)	24	129	34	183
STS-31 (61-B)	37	177	55	257
STS-32 (61-C)	20	134	39	193
STS-29	18	100	23	132
STS-28R	13	60	20	76
STS-34	17	51	18	53
STS-33R	21	107	21	118
STS-32R	13	111	15	120
STS-36	17	61	19	81
STS-31R	13	47	14	63
STS-41	13	64	16	76
STS-38	7	70	8	81
STS-35	15	132	17	147
STS-37	7	91	10	113
STS-39	14	217	16	238
STS-40	23	153	25	197
STS-43	24	122	25	131
STS-48	14	100	25	182
STS-44	6	74	9	101
STS-45	18	122	22	172
STS-49	6	55	11	114
STS-50	28	141	45	184
STS-46	11	186	22	236
STS-47	3	48	11	108
STS-52	6	152	16	290
STS-53	11	145	23	240
STS-54	14	80	14	131
STS-56	18	94	36	156
STS-55	10	128	13	143
STS-57	10	75	12	106
STS-51	8	100	18	154
STS-58	23	78	26	155
STS-61	7	59	13	120
STS-60	4	48	15	106
STS-62	7	36	16	97
STS-59	10	47	19	77
STS-65	17	123	21	151
STS-64	18	116	19	150
STS-68	9	59	15	110
STS-66	22	111	28	148
STS-63	7	84	14	125
STS-67	11	47	13	76
STS-71	24	149	25	164
STS-70	5	81	9	127
AVERAGE	13.9	90.5	20.9	130.9
SIGMA	7.2	42.8	9.9	54.2
STS-69	22	175	27	198

MISSIONS STS-23, 24, 25, 26, 26R, 27R, 30R, AND 42 ARE NOT INCLUDED IN THIS ANALYSIS
SINCE THESE MISSIONS HAD SIGNIFICANT DAMAGE CAUSED BY KNOWN DEBRIS SOURCES

Figure 7 : Orbiter Post Flight Debris Damage Summary

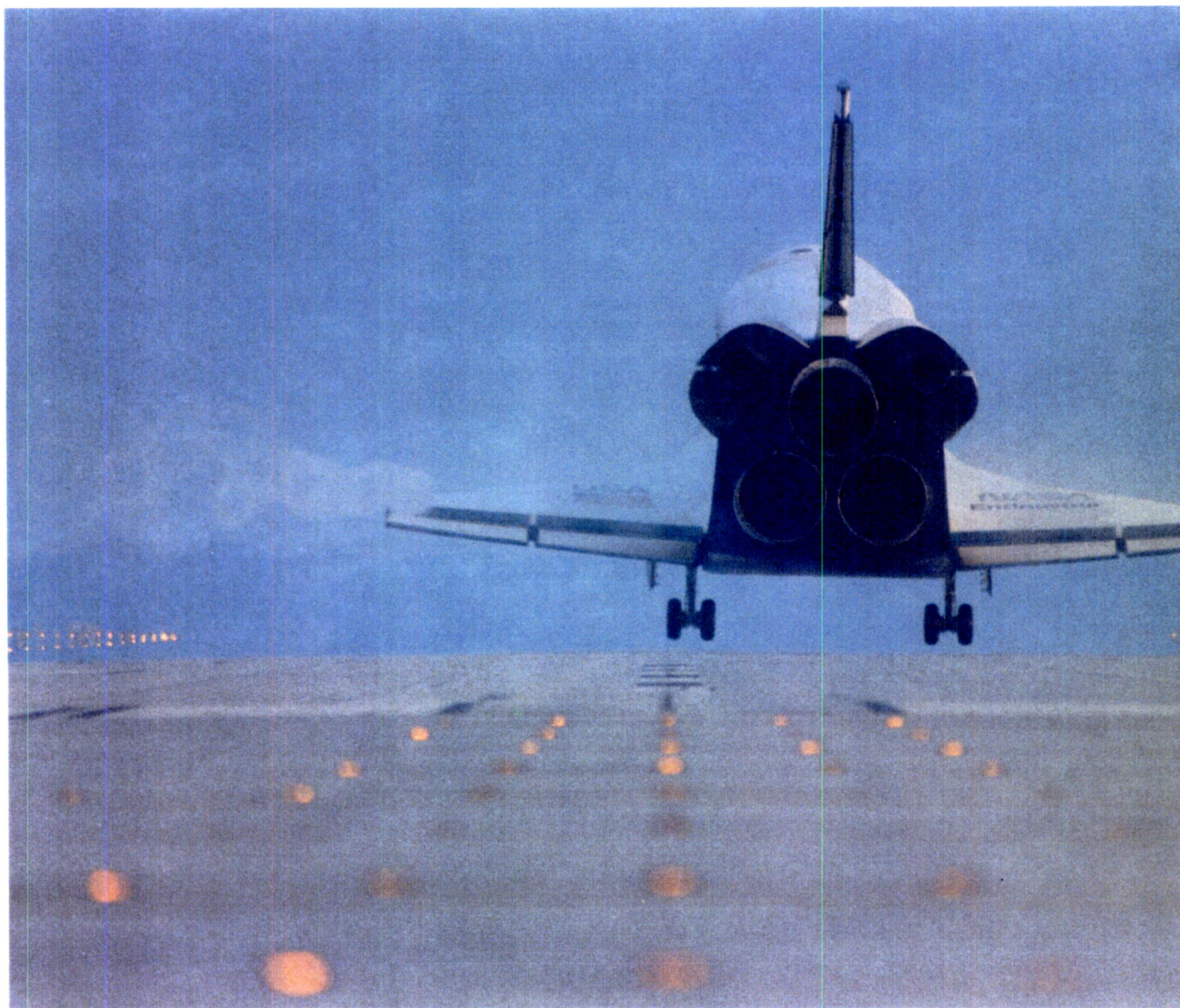


Photo 16 : OV-105 Endeavour Landing on KSC Runway 33

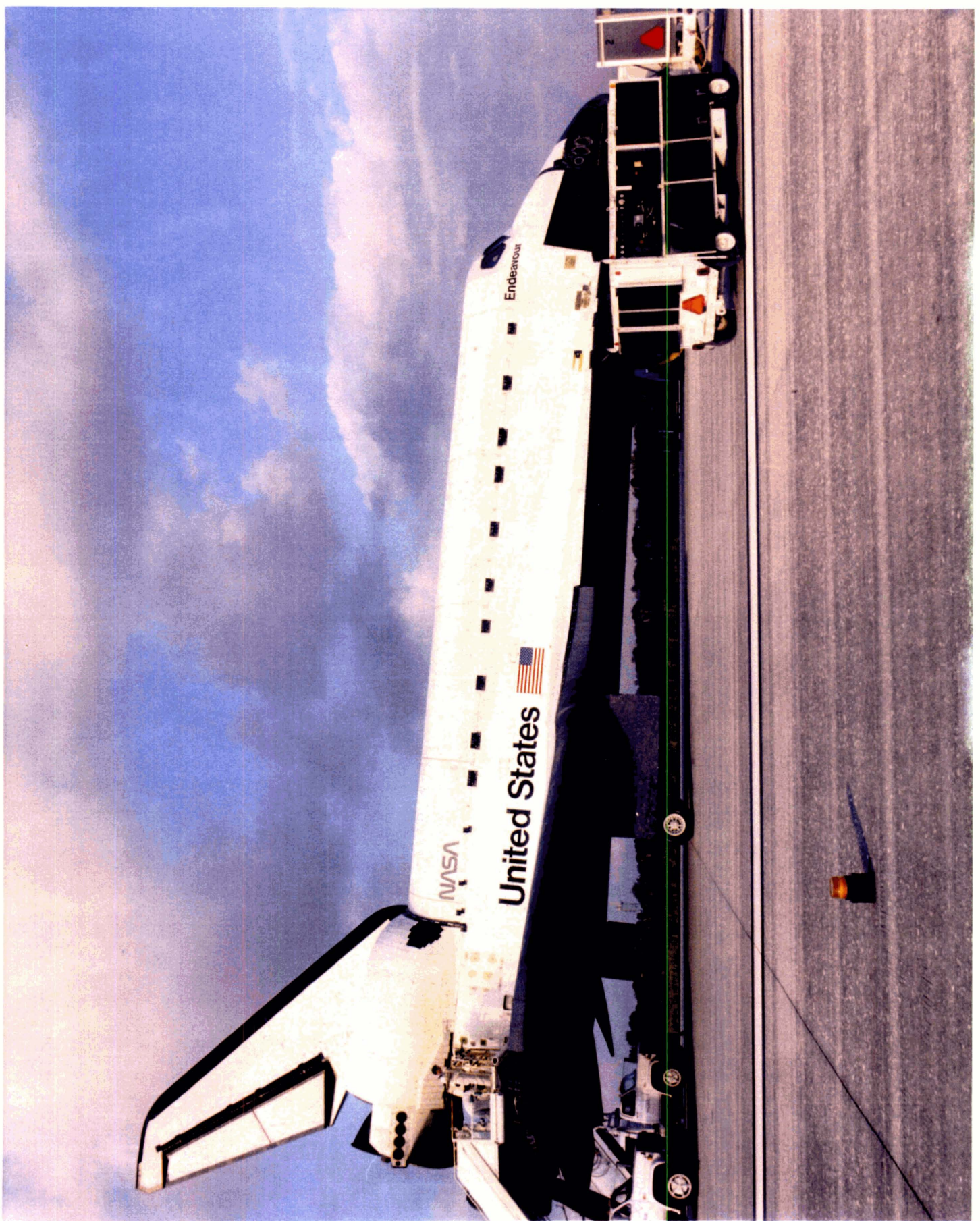


Photo 17 : Orbiter Right Side Overall View

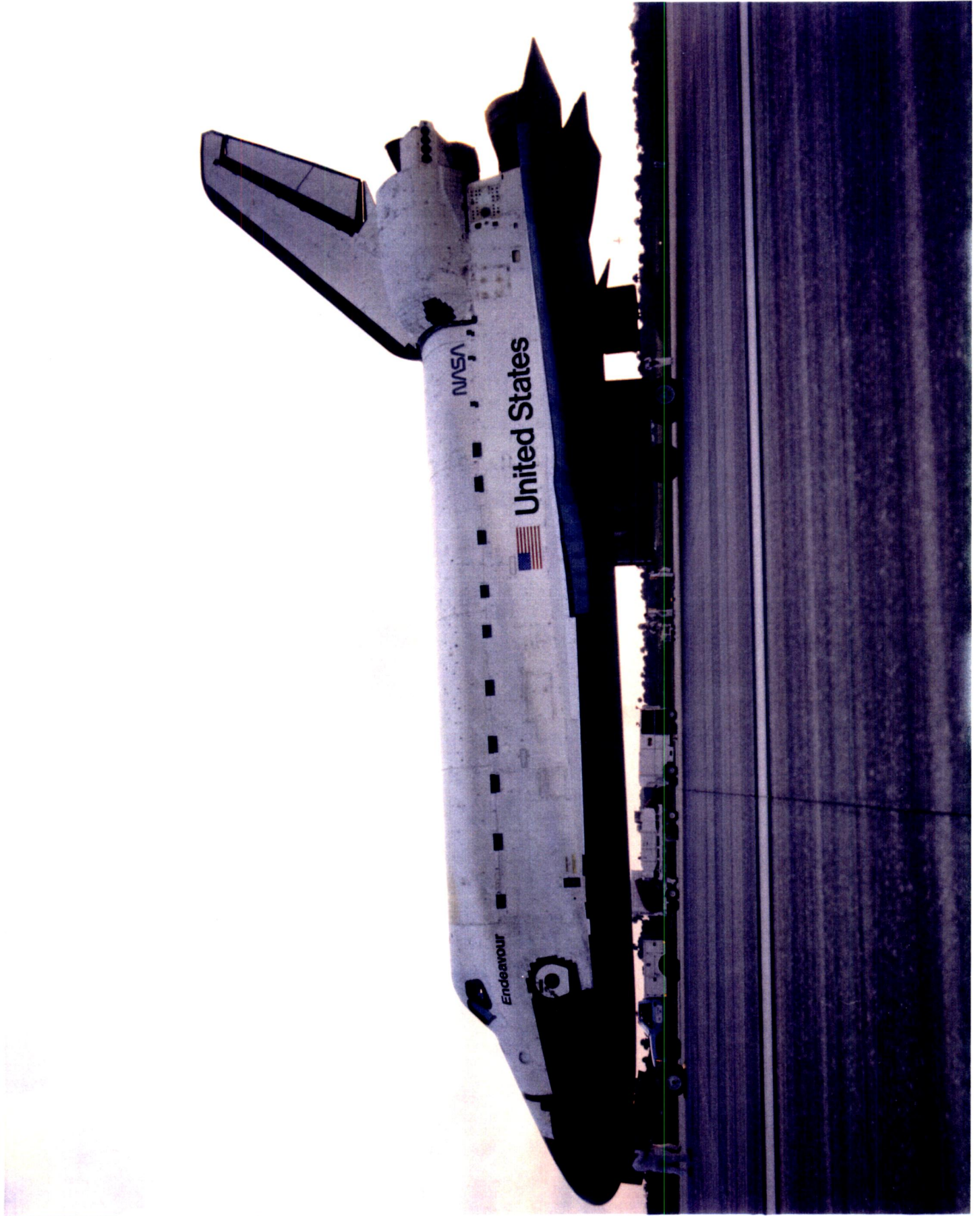


Photo 18 : Orbiter Left Side Overall View

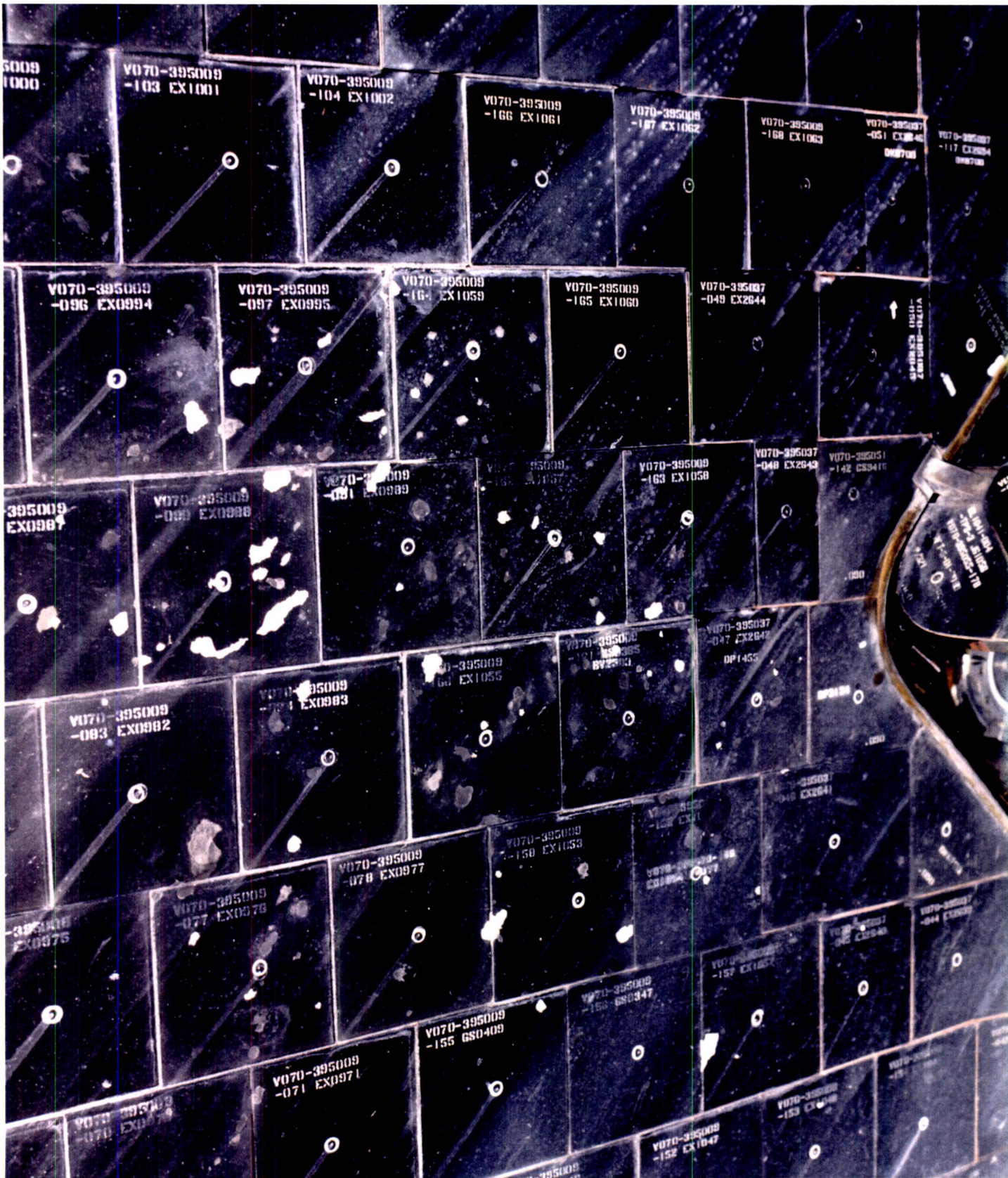


Photo 19 : Lower Surface Tile Damage

Tile damage sites aft of the LH2 ET/ORB umbilical were greater than usual in number and size (116 total with 13 larger than 1-inch). The damage was most likely caused by a combination of impacts from umbilical ice and shredded pieces of umbilical purge barrier material flapping in the airstream.

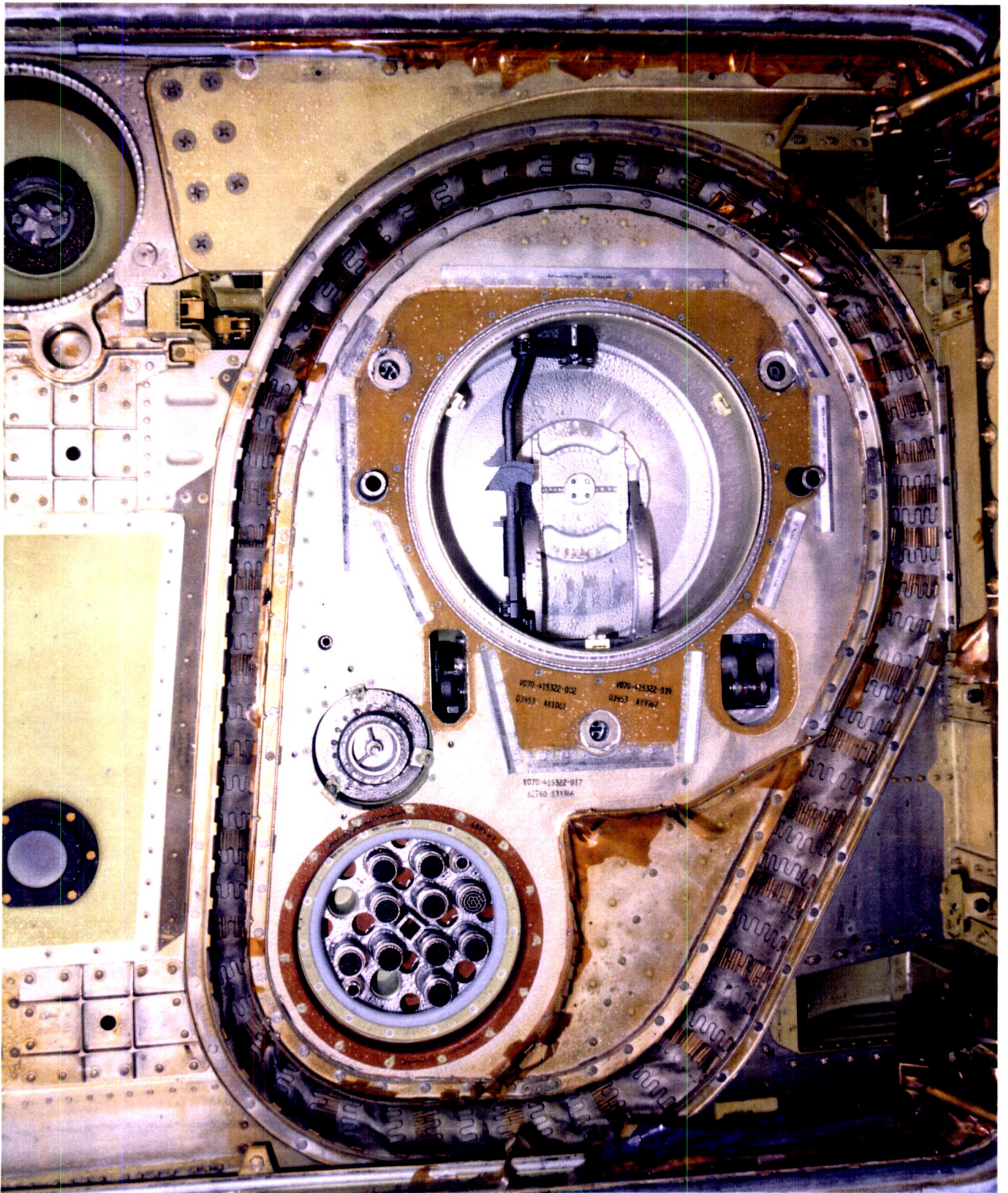


Photo 20 : LO2 ET/ORB Umbilical

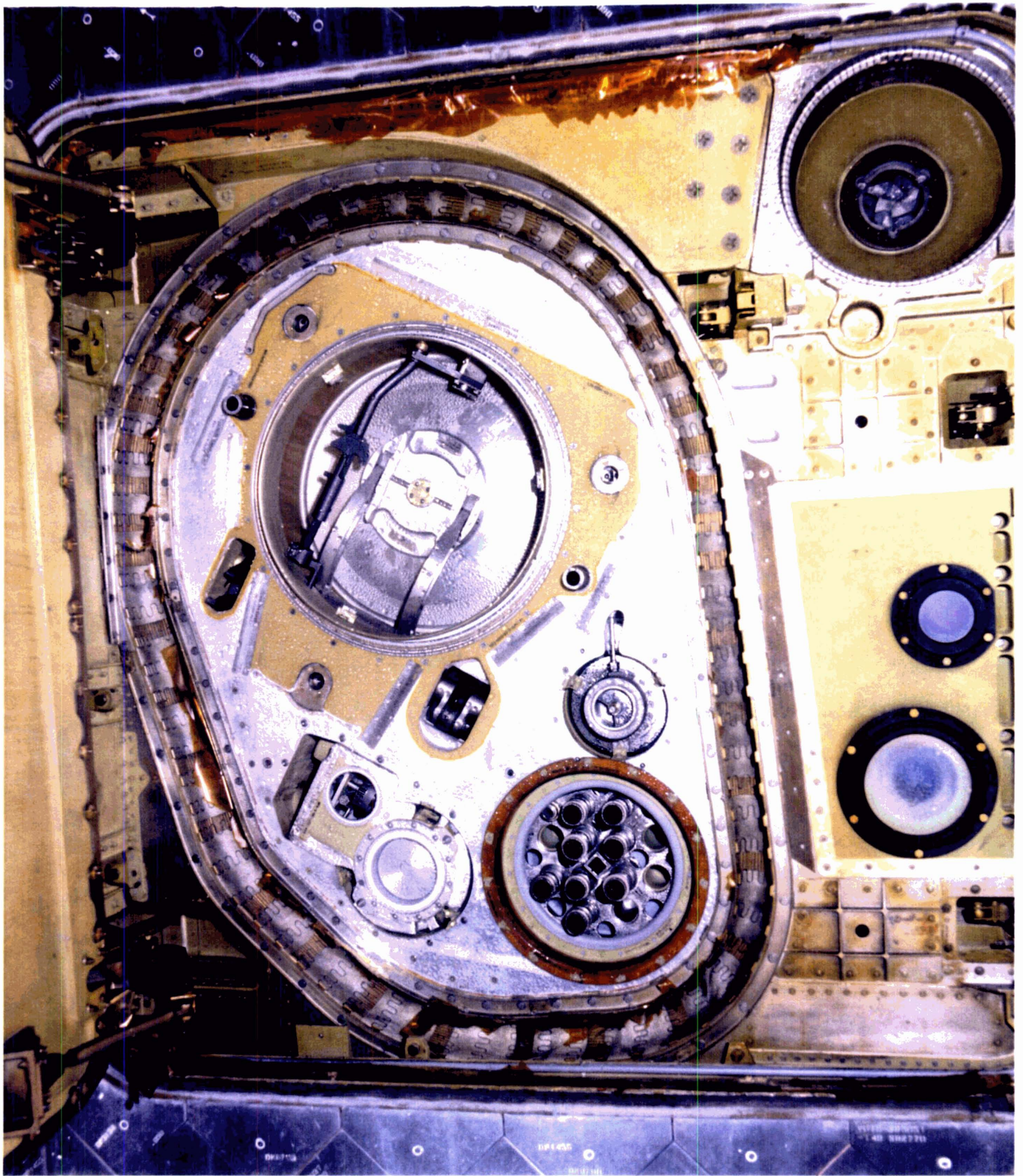


Photo 21 : LH2 ET/ORB Umbilical

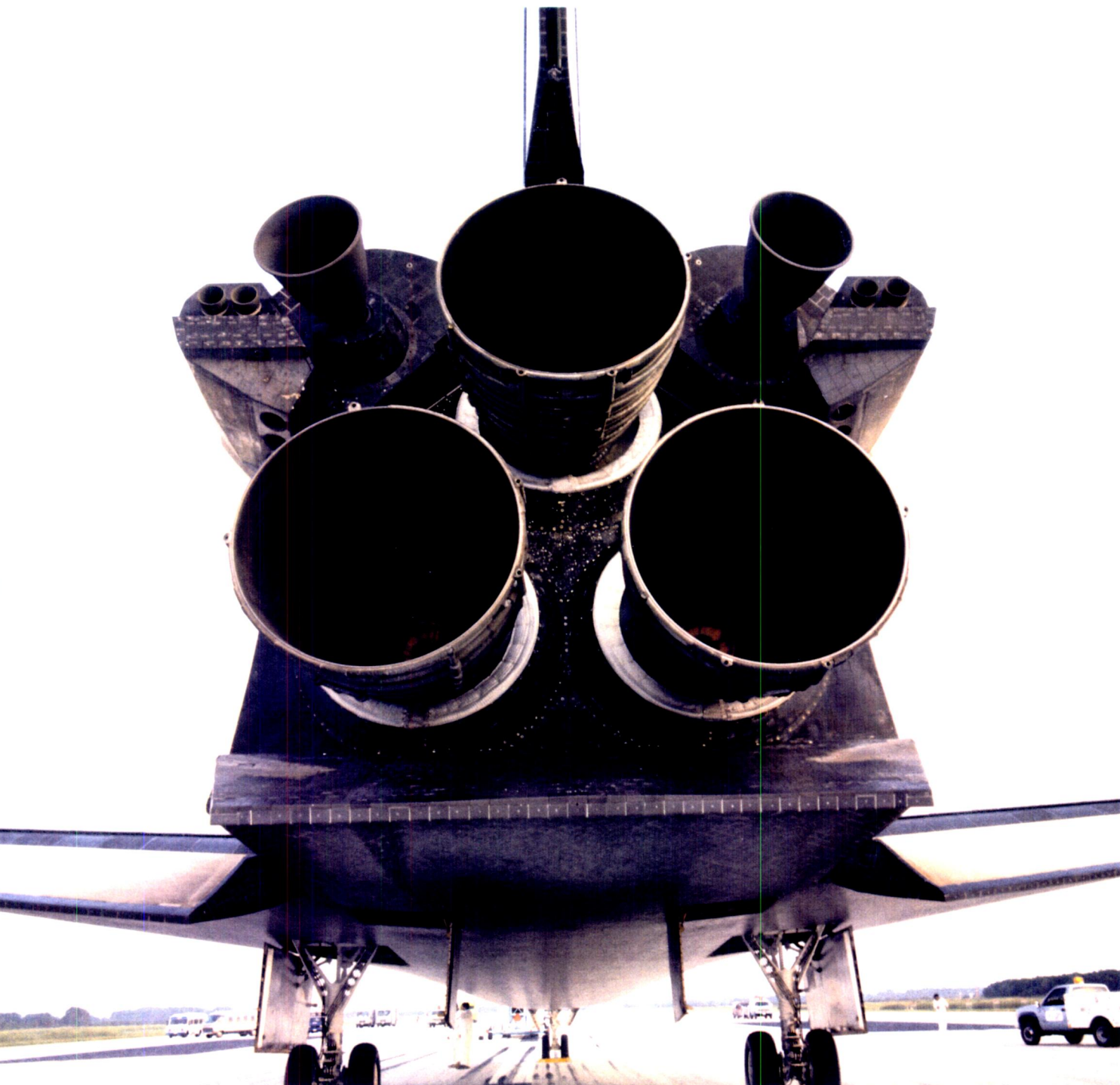


Photo 22 : Base Heat Shield

Overall view of the base heat shield. The SSME Dome Mounted Heat Shield closeout blankets were in good condition.



Photo 23 : Loose Tile on Base Heat Shield

A piece of tile, 2.25-inches long by 2-inches wide by 5/8-inch thick was loose on the base heat shield outboard of SSME #2. The filler bar was exposed when the loose piece was removed.



Photo 24 : Orbiter Windows

Orbiter windows #3 and #4 exhibited moderate hazing and streaking. A light haze was present on the other windows. Tile damage on the window perimeter tiles was concentrated above window #3. The 11 tile damage sites in this area were probably caused by impacts from FRCS paper cover pieces and RTV. Two damage sites in the space between windows #3 and #4 were also noted.

8.0 DEBRIS SAMPLE LAB REPORTS

A total of eight samples were obtained from OV-105 Endeavour during the STS-69 post landing debris assessment at Kennedy Space Center. The submitted samples consisted of 8 wipes from Orbiter windows #1-8. The samples were analyzed by the NASA KSC Microchemical Analysis Branch (MAB) for material composition and comparison to known STS materials. A specific ion chromatography testing was requested by Payload Bay contamination personnel seeking to establish source/data of observed payload bay contamination. These results are preliminary and will require additional sampling. Debris analysis involves both the placing and the correlating of particles and residues with respect to composition, thermal (mission) effects, and availability. Debris sample results/analyses are listed by Orbiter location in the following summaries.

8.1 ORBITER WINDOWS

Samples from the Orbiter windows indicated exposure to facility environment, SRB BSM exhaust (metallic particulate), landing site materials (earth minerals), Orbiter Thermal Protection System (RTV, tile, tile repair, and glass insulation), Orbiter window polish residue, paints and primer from various sources. There was no apparent vehicle damage related to these residuals.

8.2 ORGANIC ANALYSIS

The results of the STS-69 organic analysis are pending.

8.3 STS-70 ORGANIC ANALYSIS

The results of the recently-received STS-70 organic sample analysis indicated the presence of plastic polymers (Orbiter window covers), RTV (Orbiter RCS nozzle cover adhesive) and paint. These types of organic particulates were basically consistent throughout the samples and appear to be characteristic of that seen in the last several flights.

8.4 NEW FINDINGS

This set of post-flight debris residual samples led to no new findings, although the concentration of tile repair material in windows #4 and #5 (25% and 75%, respectively) suggests increased tile repair material debris. The variety of residual material continues to be representative of that documented in previous mission sampling (reference Figure 8).

STS	Sample Location				
	Windows	Wing RCC	Lower Tile Surface	Umbilical	Other
69	Metallics - Fac. Env./BSM Residue (SRB) RTV, Tile filler (ORB TPS) Insulation glass (ORB TPS) Earth minerals Building type insulation Organics Orbiter window polish residue Paint and primer				
70	Metallics - Fac. Env./BSM Residue (SRB) RTV, Tile filler (ORB TPS) Insulation glass (ORB TPS) Earth minerals Building type Insulation Organics - RTV, Plastic polymers RTV - RCS thruster nozzle cover adhesive Paint and primer				
71	Metallics - Fac. Env./BSM Residue (SRB) RTV, Tile, Tile filler (ORB TPS) Insulation Glass (ORB TPS) Earth minerals (landing site) Organics - Plastic polymers RTV - RCS thruster nozzle cover adhesive Paint and primer				
67	Metallics - Fac. Env./BSM Residue (SRB) Tile, Tile filler (ORB TPS) Insulation Glass (ORB TPS) Fiber - sample cloth Earth minerals (landing site) Organics - RTV, Plastic polymers Paint and primer				SRB sealant sample: laboratory reference
63	Metallics - Fac.Env./BSM Residue (SRB) RTV, Tile, Tile filler (ORB TPS) Insulation Glass (ORB TPS) Building type insulation Fiber-sample cloth Earth minerals (Landing site) Organics-Plastic polymers, SRB sealant RTV-RCS thruster nozzle cover Paint and primer		Silica-rich tile(ORB TPS) Hypalon paint (SRB)		

Figure 8 : Orbiter Post Landing Microchemical Sample Results

Figure 9 : Orbiter Post Landing Microchemical Sample Results

STS	Sample Location				
	Windows	Wing RCC	Lower Tile Surface	Umbilical	Other
66	Metallics - Fac.Env./BSM Residue (SRB) RTV, Tile, Tile filler (ORB TPS) Insulation Glass (ORB TPS) Fiber-sample cloth Earth minerals (Landing site) Organics-Plastic polymers, SRB sealant RTV-RCS thruster nozzle cover Paint and primer		Silica-rich tile (ORB-TPS) Hypalon paint (SRB)		
68	Metallics - Fac.Env./BSM Residue (SRB) RTV, Tile, Tile filler (ORB TPS) Insulation Glass (ORB TPS) Fiber-sample cloth Earth minerals (Landing site) Organics-Plastic polymers, SRB sealant RTV-RCS thruster nozzle cover Paint and primer		Silica-rich tile (ORB-TPS) Hypalon paint (SRB)		ET GOX Vent Seal land area and GOX Seal Sample - Metallic Particulate WINDOW DEBRIS SAMPLE - 'Butcher paper'
64	Metallics - Fac.Env./BSM Residue (SRB) RTV, Tile, Tile filler (ORB TPS) Insulation Glass (ORB TPS) Fiber-sample cloth Earth minerals (Landing site) Organics-Plastic polymers, SRB sealant RTV-RCS thruster nozzle cover Paint and primer				
65	Metallics - Fac.Env./BSM Residue (SRB) RTV, Tile, Tile filler (ORB TPS) Insulation Glass (ORB TPS) Fiber-sample cloth Earth minerals (Landing site) Organics-Plastic polymers, SRB sealant RTV-RCS thruster nozzle cover Paint and primer		Silica-rich tile (ORB-TPS) Hypalon paint (SRB)		

For data on previous missions refer to mission reports prior to STS-59

9.0 POST LAUNCH ANOMALIES

Based on the debris walkdowns and film/video review, 5 post launch anomalies, but no In-Flight Anomalies (IFA's), were observed on the STS-69 mission.

9.1 LAUNCH PAD/SHUTTLE LANDING FACILITY

1. No significant items.

9.2 SOLID ROCKET BOOSTERS

1. The number of debonds (80) over RH frustum fasteners was greater than average. The number of MSA-2 debonds (63) over LH frustum fasteners was also greater than average.

9.3 EXTERNAL TANK

1. Numerous small areas of topcoat from the External Tank nose cone adhered to the lower areas of both +Y and -Y GOX seals. A larger area of topcoat, 3 inches long by 1.5 inches wide, adhered to the northeast seal, but no foam residue from the ET was present. The seals stuck momentarily to the ET nose cone during GOX vent hood retraction at T-2:30 minutes.
2. The LO2 ET/ORB umbilical sustained minor TPS damage on the forward surface. Numerous divots and eroded areas were visible on the horizontal and vertical sections of the cable tray. The lightning contact strip across the forward part of the umbilical was missing. Loss of lightning contact strips was the subject of a previous IFA.

9.4 ORBITER

1. Tile damage on the window perimeter tiles was concentrated above window #3. The 11 tile damage sites in this area were probably caused by impacts from FRCS paper cover pieces and RTV. A large damage site on a window #5 perimeter tile and two damage sites in the space between windows #3 and #4 were also noted.
2. A 7-inch long by 1-inch wide Ames gap filler from the nose landing gear door was found on the runway at the Orbiter wheel stop location.

APPENDIX A. JSC PHOTOGRAPHIC ANALYSIS SUMMARY

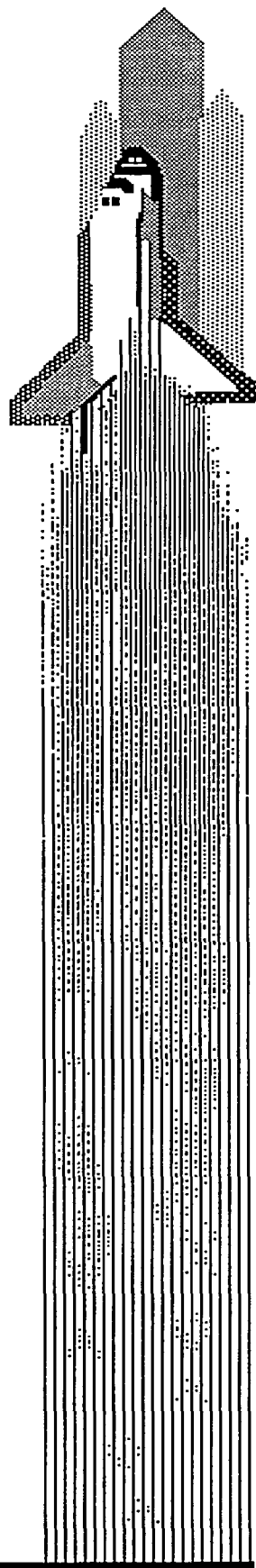
Space Shuttle

Earth Science Branch

Image Science and
Analysis Group

STS-69 Summary of Significant Events

October 18, 1995



Space Shuttle Image Science and Analysis Group

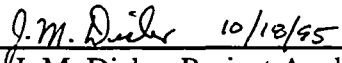
STS-69 Summary of Significant Events


Project Work Order - SN-5CR


Approved By

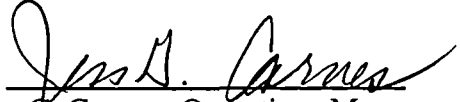
Lockheed Martin

NASA


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Earth Science Branch


M. H. Trenchard, Project Manager
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Lockheed Martin Engineering and Sciences Company
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1. STS-69 (OV-105): Film/Video Screening and Timing Summary

1. STS-69 (OV-105): FILM / VIDEO SCREENING AND TIMING SUMMARY

1.1 SCREENING ACTIVITIES

1.1.1 Launch

The STS-69 launch of Endeavour (OV-105) from pad A occurred on Thursday, September 7, 1995 (day 250) at 15:09:00.005 Coordinated Universal Time (UTC) as seen on camera E8. Solid Rocket Booster (SRB) separation occurred at 15:11:02.448 UTC as seen on camera KTV13.

On launch day 24 of 24 expected videos were received and screened. Following launch day, 51 films were screened. Camera films E65 and E79 were not received. No potential anomalies were observed during launch.

Detailed Test Objective 312, photography of the external tank after separation, was performed using the Orbiter umbilical well cameras (method 1). The handheld Nikon camera with a 300 mm lens and 2X extender was also used on STS-69 (method 3), but the handheld film was unusable due to the small image size of the external tank.

1.1.2 Landing

Endeavour landed on runway 33 at KSC on September 18, 1995. Ten videos of the Orbiter's approach and landing were received.

No major anomalies were noted in any of the approach, landing, and roll-out video views screened.

1.2 TIMING ACTIVITIES

Launch:

Video cameras: All videos had timing.

Film cameras: E1, E2, E3, E4, E5, E6, E7, E8, E9, E10, E11, E12, E13, E14, E15, E16, E17, E18, E19, E20, E25, E26, E30, E31, E33, E34, E35, E36, E40, E52, E54, E57, E59, E60, E62, E63, E76, E77, E222, and E224 had in-frame alphanumeric timing. The time codes from videos and films were used to identify specific events during the initial screening process.

Landing:

Ten videos were screened on landing day. Nine videos: EL17IR, KTV11L, KTV13L, KTV15L, KTV20L, KTV33L, KTV5L, KTV6L, SLF S had timing. There was no IRIG timing for the SLF North video.

1. STS-69 (OV-105): Film/Video Screening and Timing Summary

Event Description	Time (UTC)	Camera
Landing gear - doors opened	261:11:37:37.784	KTV33L
<i>Touchdown</i>		
Right Main Wheel	261:11:37:54.743	SLF-South
Left Main Wheel	261:11:37:54.810	SLF-South
Nose Wheel	261:11:38:08.081	KTV33L
Wheel stop	261:11:38:54.520	KTV15L

Table 1.2.2: Landing Video Timing Events

2. Summary of Significant Events

2. SUMMARY OF SIGNIFICANT EVENTS

2.1 DEBRIS

2.1.1 Debris Near the Time of SSME Ignition

2.1.1.1 LH2 and LO2 ET/Orbiter Umbilical Disconnect Debris

(Cameras: OTV009, OTV054, OTV061, OTV063, E1, E4, E5, E6, E16, E31, E34, E36, E40, E41, E52)

Normal ice debris was noted falling from the LH2 and LO2 ET/Orbiter umbilical disconnect areas at SSME ignition through liftoff. No follow-up action was requested.

2.1.2 Debris Near the Time of SRB Ignition

2.1.2.1 SRB Flame Duct Debris

(Cameras: E1, E3, E7, E8, E9, E12, E13, E14, E15, E16, E60, E63, E77)

As on previous missions, debris was noted originating from the SRB flame duct area after SRB ignition.

A single dark colored rope-like piece of debris was first seen near the RSRB and moved to the right of the field of view where it was obscured by FSS deluge water at 1 second MET. No follow-up action was requested.

A single large, red piece of debris (probably flame duct water baffle material) was seen moving through the field of view from left to right at 0.6 seconds MET near the LSRB holddown post M-5. No follow-up action was requested.

Two dark colored pieces of debris (possibly water baffle material) were seen in the SRB plume after liftoff at 1.2 seconds MET. No follow-up action was requested.

2.1.2.2 LH2 and LO2 Tail Service Mast (TSM) T- 0 Umbilical Disconnect Debris (Cameras: OTV049, OTV050, E17, E18, E19, E20, E31, E63, E76, E77)

Normal ice debris was noted falling from the LH2 and LO2 TSM T-0 umbilical disconnect areas at liftoff. None of the debris was observed to strike the vehicle. No follow-up action was requested.

2.1.2.3 GH2 Vent Arm Debris During Disconnect and Retraction (Cameras: E33, E34, E35, E50, E54, E59, E60)

Vapor and multiple light colored pieces of ice debris fell from the GH2 vent arm carrier plate at vent arm retraction. The GH2 vent arm appeared to retract normally.

2. Summary of Significant Events

2.1.2.4 Debris at T-5.1 seconds (Camera: E77)



Figure 2.1.2.4 A Single Dark Piece of Debris seen Under SSME #2 at T-5.1 Seconds

A single dark piece of debris, probably a piece of ice, was first seen under SSME #2 and fell aft. No follow-up action was requested.

2.1.2.5 Debris at T-2.2 seconds (Camera: E16)

Several (at least three) dark colored pieces of debris were seen falling aft of the vertical stabilizer during SSME ignition. No follow-up action was requested.

2.1.2.6 Debris at SRB Ignition (Camera: E10)

A single dark, thin piece of debris noted near the RSRB holddown post M-3 was seen moving in a westward direction at SRB ignition. No follow-up action was requested.

2.1.3 Debris After Liftoff

Multiple pieces of debris were seen falling aft of the Shuttle Launch Vehicle (SLV) at liftoff, throughout the roll maneuver and beyond on the launch tracking views. The debris was probably reaction control system (RCS) paper or ice from the ET/Orbiter umbilicals. No follow-up action was requested.

2. Summary of Significant Events

2.1.3.1 Debris at 1 second MET (Cameras: E19, E76, E77)

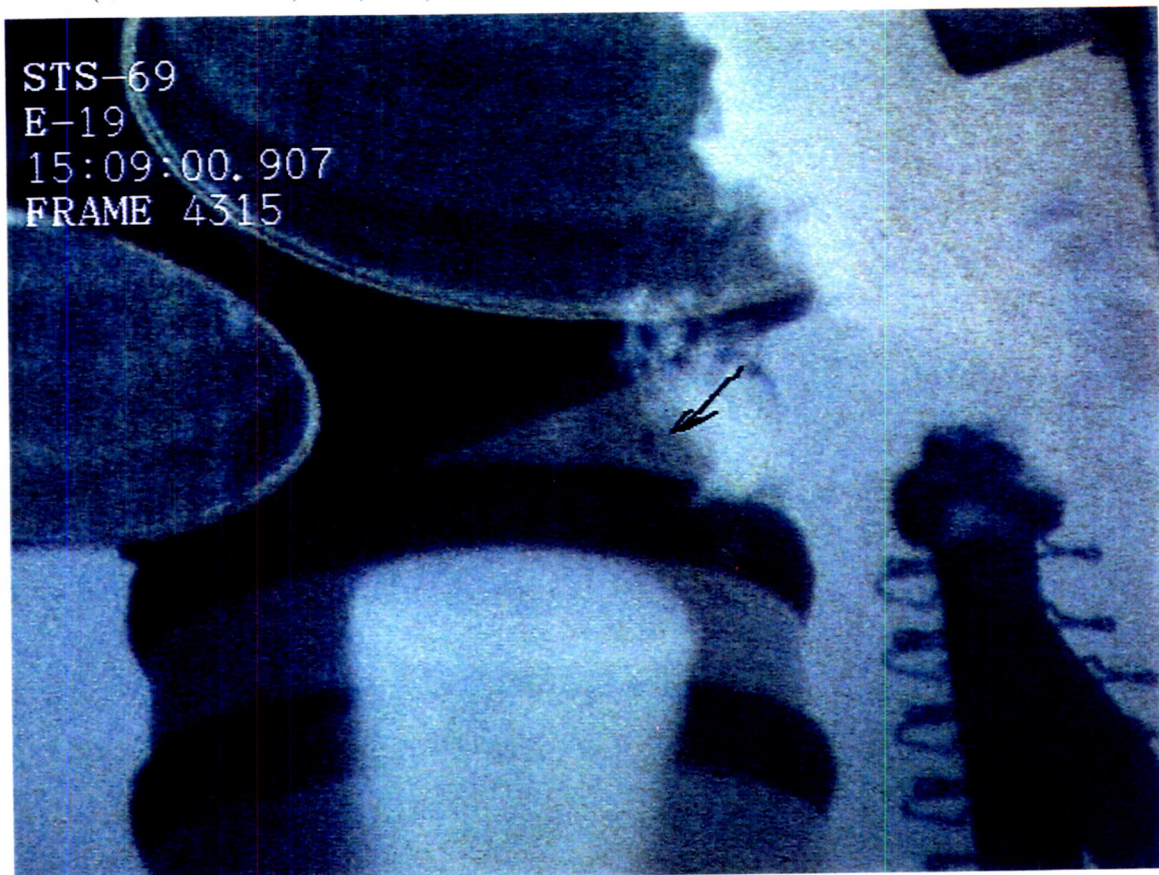


Figure 2.1.3.1 A Single Dark Piece of Debris seen Under SSME #3 at 1 Second MET

A single dark piece of debris was first seen under SSME #3 and fell aft. This piece of debris was first seen under SSME#2 on film item E77. KSC believes that this debris may be a 6-inch long by 2-inch wide gap filler found missing from the hinge line between SSME #2 and #3 during the STS-69 Orbiter Post Landing Inspection Debris Assessment. No follow-up action was requested.

2.1.3.2 Debris at 1.5 seconds MET (Camera: E4)

Two large pieces of light colored debris were seen at 1.5 seconds MET. One piece of debris was seen near the ET and the other near the left wing tip. No follow-up action was requested.

2. Summary of Significant Events

2.1.3.3 Debris at 1.7 seconds MET

(Camera: E77)



Figure 2.1.3.3 A Single Light Colored Rope-like Piece of Debris seen Coming from the RSRB Plume at 1.7 Seconds MET

A single light colored rope-like, flexible piece of debris was seen coming from the RSRB plume at 1.7 seconds MET. The debris was seen moving towards the LO2 TSM T-0 tower before it was lost from view. No follow-up action was requested.

2.1.3.4 Debris at 2 seconds MET

(Camera: E76)

A single light colored piece of debris first seen near the left SRB aft skirt area at holddown post M-6 was seen falling aft of the vehicle. No follow-up action was requested.

2.1.3.5 Debris at 8 seconds MET

(Camera: E222)

A single light colored piece of debris fell aft of the Shuttle Launch Vehicle (SLV) into the SRB plume. No follow-up action was requested.

2. Summary of Significant Events

2.1.3.6 Debris at 16 seconds MET

(Camera: E54, E213)

Multiple light colored pieces of debris, first seen between the SRBs, fell aft of the launch vehicle at 16 seconds MET (E54). Multiple (at least three) light colored pieces of debris (probably forward RCS pacer) were first seen over the left inboard elevon and fell into the SRB exhaust plume at approximately 16 seconds MET (E213). No follow-up action was requested.

2.1.3.7 Debris at 21, 24 and 34 seconds MET

(Camera: E213, E220)

Multiple (at least three) light colored pieces of debris were first seen between the SRBs and fell aft into the SRB exhaust plume at 21 seconds MET (E213). Multiple light colored pieces of debris were seen falling aft of the vehicle at 24 and 34 seconds MET (E220). No follow-up action was requested.

2.1.3.8 Debris Reported by the Crew (Task #10)

The transcript of the crew debris report is as follows:

Capcom: Endeavour, Houston, when you get a chance we are ready to listen to your debris report.

Endeavour: Houston, Endeavour we are ready to give our debris report.

Capcom: Go ahead, Endeavour.

Endeavour: OK, debris report; everything looks fairly nominal. Just with respect to smudging on the windows, we have about 20 percent of the window smudged on window 3. There is about half that on window 4. There is the usual thin cloud of stuff which (audio break-up, could not determine what was being downlinked) on both windows, about the same amount, my window has a few more splotches, but I think they are both usable.

Capcom: Endeavour, we copy your debris report.

The End.

2.2 MOBILE LAUNCH PLATFORM (MLP) EVENTS

2.2.1 Orange Vapor

(Cameras: E36)

Orange vapor (possibly free burning hydrogen) was seen under the body flap just prior to SSME ignition. Orange vapor has been seen on previous missions. No follow-up action was requested.

2. Summary of Significant Events

2.2.2 Flexing of the Orbiter Base Heat Shield (Camera: E76)

Flexing of the Orbiter base heat shield was seen between the SSME cluster at SSME ignition. Flexing of the base heat shield has been seen on previous missions. No follow-up action was requested.

2.2.3 Base Heat Shield Erosion (Cameras: E17, E19, E20)

Slight erosion of the tile surface coating material was seen on the base heat shield and the base of the left RCS stinger at SSME start-up. Heat shield erosion has been seen on previous missions. No follow-up action was requested.

2.2.4 PIC Wire Remained Attached to Shoe (Cameras: E8, E9)

Two PIC wires remained attached to the holddown post foot after the foot had cleared the holddown post shoe at liftoff. One wire was on the RSRB HDP M-1 and the other wire was on the RSRB HDP M-2. This event has been observed on other missions and is not anomalous. No follow-up action was requested.

2.2.5 Orange-Colored Flash (Cameras: E2, E3, E5, E62, E77)

An orange-colored flash was seen in the SSME #1 exhaust plume prior to liftoff at T-1.4 seconds MET. This event has been seen on previous missions. No follow-up action was requested.

2.2.6 RSRB HPU Venting (Camera: E222)

White puffs were visible from the RSRB Hydraulic Power Unit (HPU) exhaust port during liftoff. No follow-up action was requested.

2.3 ASCENT EVENTS

2.3.1 Body Flap Motion (Task #4) (Cameras: E25, E220)

Only slight body flap motion was visible during this mission. Therefore, the magnitude of the body flap motion will not be measured.

2. Summary of Significant Events

2.3.2 Flares in SSME Exhaust Plume

(Camera: E19)

An orange-colored flare was seen in the SSME #3 exhaust plume at approximately 0.8 seconds MET.

(Cameras: E2, E3, E5)

An orange-colored flare was seen in the SSME #2 exhaust plume at 1.3 seconds MET.

(Camera: E52)

An orange-colored flare was seen in the SSME #1 exhaust plume at 9.6 seconds MET.

(Cameras: E220, E222)

An orange-colored flare was seen in the SSME exhaust plume after liftoff at approximately 33 seconds MET.

(Camera: E220)

An orange-colored flare was seen in the SSME plume at 37 seconds MET.

Orange colored flares in the SSME exhaust plume have been seen on previous missions. No follow-up action was requested.

2.3.3 Streak in SSME Exhaust Plume

(Camera: E52)

A light colored streak was seen in the SSME plume (well aft of the vehicle) at 9.2 seconds MET. No follow-up action was requested.

2.3.4 Condensation

(Cameras: E205, E212, E213, E218, E220, E222, E223)

Condensation was seen around the Shuttle Launch Vehicle between 38 and 54 seconds MET. No follow-up action was requested.

2.3.5 Recirculation

(Cameras: ET212, E208, E212)

The recirculation or expansion of burning gases at the aft end of the Shuttle Launch Vehicle (SLV) prior to SRB separation has been seen on nearly all previous missions. For STS-69, the start of recirculation was observed at approximately 91 seconds MET and the end was noted at approximately 101 seconds MET. No follow-up action was requested.

2. Summary of Significant Events

2.4 ONBOARD PHOTOGRAPHY OF THE EXTERNAL TANK (DTO-312)

2.4.1 Analysis of the STS-69 Handheld External Tank Pictures (Task #5)

DTO-312 handheld photography of the STS-69 external tank (after separation) was acquired with a Nikon camera with a 300 mm lens and a 2X extender (Method 3). This film was evaluated as unusable for analysis since the image size of the external tank was extremely small. The tank was calculated to be a distance of 17 kilometers away from the Orbiter on the first image (taken 32.5 minutes after liftoff). The pitch maneuver for photographing the external tank was not performed on STS-69.

2.4.2 Analysis of the Umbilical Well Camera Films (Task #5)

Three rolls of STS-69 umbilical well camera film were received at JSC: the 35 mm film from the LO2 umbilical and two 16 mm films (5 mm lens and 10 mm lens) from the LH2 umbilical. The +X translation maneuver was not performed on STS-69.

Unidentified Debris Object:

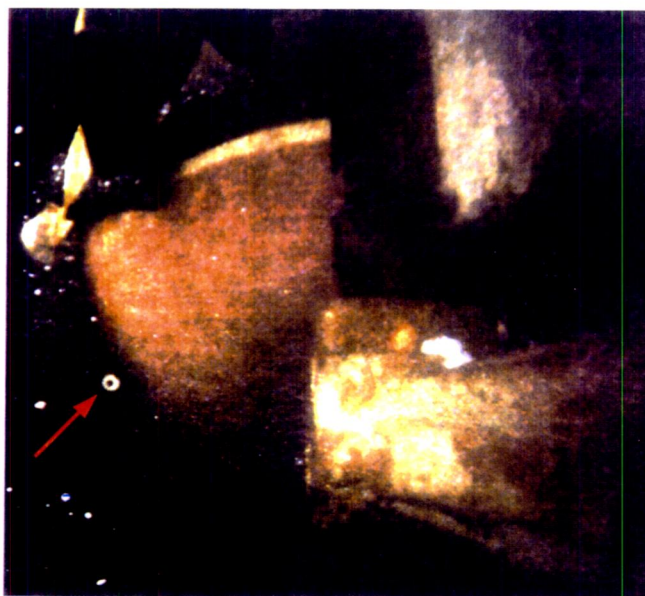


Figure 2.4.2 (A) Unidentified Circular Debris Object seen on the 16 mm (5 mm lens) Umbilical Well Film

An unknown highly reflective, thin, circular object with a circular hole in the center was seen near the electric cable tray and tumbled away from the Shuttle on the 16 mm umbilical well films. A phototheodolite analysis was used to measure the size and motion of the debris. This method uses the images of the debris from the two 16 mm umbilical cameras. The position of the debris relative to the cameras was calculated assuming that the cameras had the same time interval

2. Summary of Significant Events

between frames. Data was collected on the center point of the debris, the outside diameter of the debris, the diameter of the hole in the center of the debris, and the thickness of the debris. The debris was characterized as follows:

Outer diameter :	0.48	± 0.17 inches
Inner diameter :	0.19	± 0.08 inches
In/Out diameter ratio :	0.40	
Thickness :	0.17	± 0.10 inches
Velocity :	~ 1.4	feet/sec

The results of this analysis were provided to the JSC Propulsion and Power Division / EP.

The following items seen on the umbilical well films are not considered anomalous but do merit mentioning:

35 mm LO2 Umbilical Film Screening:

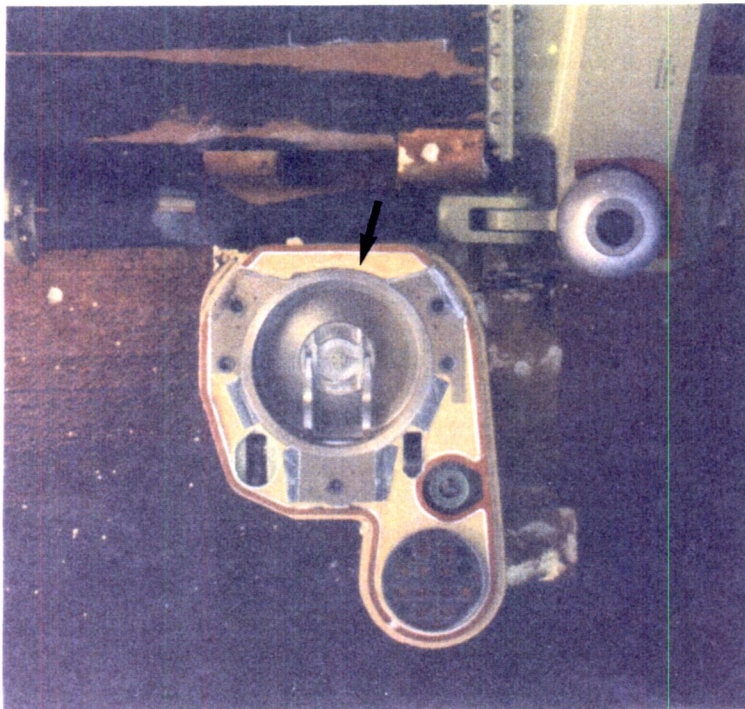


Figure 2.4.2 (B) Missing Lightning Contact Strip at the 12 o'clock Position Forward of the LO2 17 Inch Line Orifice.

The lightning contact strip at the 12 o'clock position forward of the LO2 17 inch line orifice is missing. LO2 umbilical lightning contact strip(s) were noted to be missing on STS-57, STS-58, STS-65, STS-66, STS-71 and other previous mission umbilical well films. Missing lightning contact strips were covered on a previous IFA.

Multiple small white debris objects are visible through out the film sequence. These white debris objects appear to be frozen hydrogen.

2. Summary of Significant Events

Note: Light reflections were visible through out the entire film sequence. The 35 mm LO2 umbilical film ended prior to imaging of the ET intertank.

16 mm LH2 Umbilical Well Film Screening (5 mm & 10 mm Lens):

Numerous light colored pieces of debris (probably insulation) are in view throughout the SRB film sequence. Typical chipping and erosion of the electric cable tray are visible. Multiple pieces of white debris (frozen hydrogen) were visible throughout the ET separation sequence. These events are typical of those seen on previous mission umbilical well camera views.

2.5 LANDING EVENTS

2.5.1 Landing Sink Rate Analysis (Task #3)

The main gear sink rate of the Orbiter was determined over a one second time period prior to main gear touchdown. Also, the nose gear sink rate was determined over a one second time period prior to the nose gear touchdown.

The measured main gear and nose gear sink rate values were found to be below the maximum allowable values of 9.6 ft/sec for a 211,000 lb. vehicle and 6.0 ft/sec for a 240,000 lb. vehicle (the landing weight of the STS-69 Orbiter was reported to be 219,377 lbs.). The sink rate measurements for STS-69 are given in Table 2.5.1. In Figures 2.5.1 (A) and 2.5.1 (B) the trend of the measured data points for both film camera image data and video image data are illustrated.

Prior to Touchdown (1 sec)	Sink Rate: Film	Sink Rate: Video
Main Gear	4.5 ft/sec	4.2 ft/sec
Nose Gear	4.8 ft/sec	4.8 ft/sec

Table 2.5.1: Sink Rate Measurements

2. Summary of Significant Events

STS-69 Main Gear Sink Rate

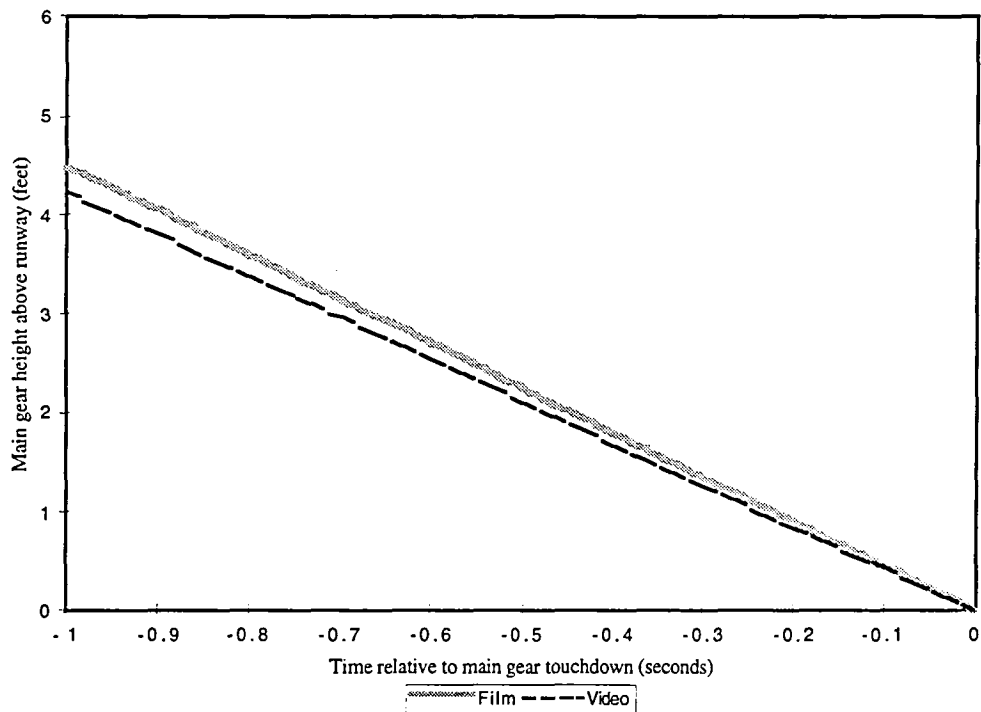


Figure 2.5.1 (A) Main Gear Sink Rate from Film (EL9) and Video (Runway South) (shown as trend of data points)

STS-69 Nose Gear Sink Rate

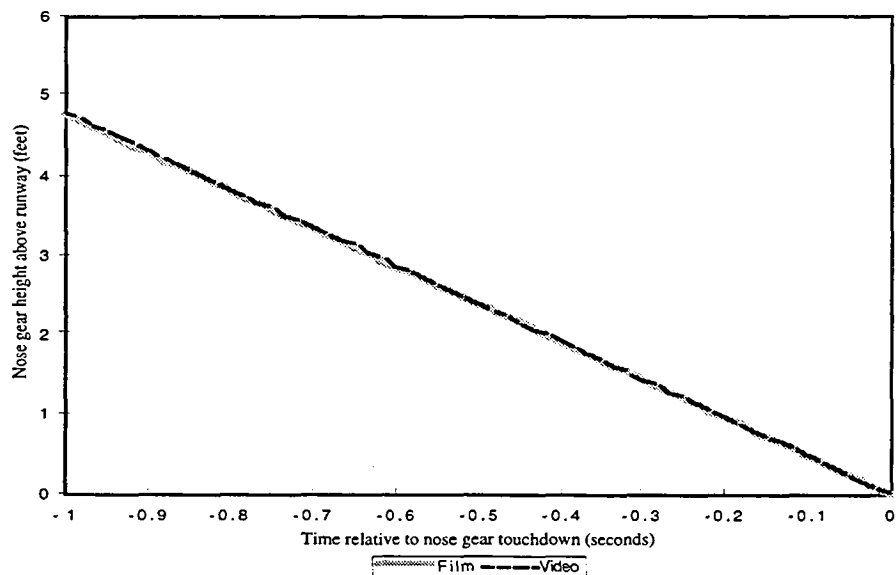


Figure 2.5.1 (B) Nose Gear Sink Rate from Film (EL1) and Video (Runway North) (shown as trend of data points)

2. Summary of Significant Events

2.5.2 Orbiter Height above Threshold (Task #13)

The Orbiter height above threshold for the STS-69 mission was measured to be a distance of 17.2 feet between the bottom of the main gear tire and the runway surface as the Orbiter passed over the runway threshold during final approach. The image resolution and photogrammetric error considerations indicate an error of +/- 3 inches for this measurement.

2.6 OTHER

2.6.1 Normal Events

Other normal events observed include: normal SSME ignition sequence, RCS paper debris at SSME ignition, slight body flap and inboard and outboard elevon motion at SSME ignition, debris on/near the MLP during SSME start-up through liftoff, ET twang, LH2 and LO2 TSM T-0 door closure, overshoot of the roll maneuver, acoustic waves at liftoff, bird in the vicinity of the Shuttle Launch Vehicle at liftoff, RCS paper after liftoff, ET aft dome outgassing after liftoff, slight body flap motion after the roll maneuver, SRB plume brightening, SRB separation.

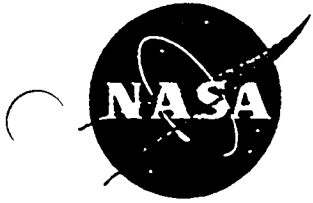
Normal events seen that are related to the pad are hydrogen ignitor operation, fixed service structure (FSS) deluge water activation, GH2 vent arm retraction, sound suppression water initiation, mobile launch platform (MLP) water dump activation.

Other

J-pipe water leaks were noted near the SRB holddown posts M-3, M-7 and M-8.

Multiple light colored pieces of debris (probably ice) fell from the MLP at liftoff.

APPENDIX B. MSFC PHOTOGRAPHIC ANALYSIS SUMMARY



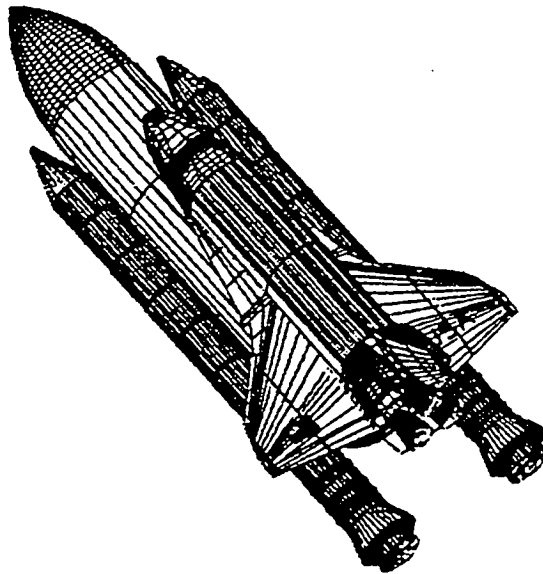
National Aeronautics and
Space Administration

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

SPACE SHUTTLE

ENGINEERING PHOTOGRAPHIC ANALYSIS REPORT

STS-69



ENGINEERING PHOTOGRAPHIC ANALYSIS REPORT


STS-69

FINAL

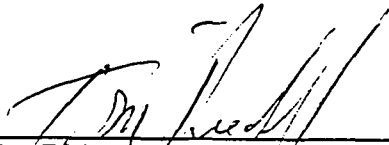
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STS-69 ENGINEERING PHOTOGRAPHIC ANALYSIS REPORT

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October 2, 1995

I. INTRODUCTION

The launch of space shuttle mission STS-69, the ninth flight of the Orbiter Endeavour occurred on September 7, 1995, at approximately 10:09 A.M. Central Daylight Time from Launch Complex 39A (LC-39A), Kennedy Space Center (KSC), Florida.

Extensive photographic and video coverage exists and has been evaluated to determine proper operation of the ground and flight hardware. Cameras (video and cine) providing this coverage are located on the fixed service structure (FSS), mobile launch platform (MLP), LC-39B perimeter sites, onboard the vehicle, and uprange and downrange tracking sites.

II. ENGINEERING ANALYSIS OBJECTIVES:

The planned engineering photographic and video analysis objectives for STS-69 included, but were not limited to the following:

- a. Overall facility and shuttle vehicle coverage for anomaly detection
- b. Determination of SRB PIC firing time and SRB separation time
- c. Verification of Thermal Protection System (TPS) integrity
- d. Correct operation of the following:
 1. SSME ignition
 2. SRB debris containment system
 3. LH2 and LO2 17" disconnects
 4. Ground umbilical carrier plate (GUCP)
 5. Free hydrogen ignitors
 6. Booster separation motors (BSM)
 7. Vehicle clearances
 8. Vehicle motion
- e. Verification of cameras, lighting and timing systems

III. CAMERA COVERAGE ASSESSMENT:

Film was received from fifty of fifty-two requested cameras as well as video from twenty-four of twenty-four requested cameras. The following table illustrates the camera data received at MSFC for STS-69.

**Camera data received at MSFC
for STS-69**

	16mm	35mm	Video
MLP	22	0	4
FSS	7	0	3
Perimeter	1	3	6
Tracking	0	15	11
Onboard	2	0	0
Totals	32	18	24

Total number of films and videos received: 74

The individual motion picture and video camera assessments are available on the Engineering Photographic Analysis server on the World Wide Web. The server address is <http://photo4.msfc.nasa.gov/msfc.html>

a. Ground Camera Coverage:

All ground cameras operated properly. Cameras E65 and E79 which are located at camera site 39A-2 where obscured by water on their lenses. Tracking data was limited because of the high moisture content and cloud coverage in the atmosphere at the time of launch.

b. Onboard Camera Coverage:

The orbiter Endeavour carried two 16mm motion picture cameras in the LH2 umbilical well to record the SRB and ET separation events. A 35mm sequential still camera was flown in the L02 umbilical well to record the ET after separation. All umbilical well cameras operated properly.

IV. ANOMALIES/OBSERVATIONS:

No anomalies or issues have been observed to date from either film or video. All MSFC elements appeared to perform as expected. The events typically observed during a launch such as the usual amounts of ice/frost at the disconnects and umbilicals were observed along with butcher paper and hydrogen fire detection paper falling aft during ascent.

At approximately T-1.5 seconds MET, the plume in SSME #1 was discolored orange for approximately 10 milliseconds. Figure 1 is a film frame from camera E-2 showing the discoloration.

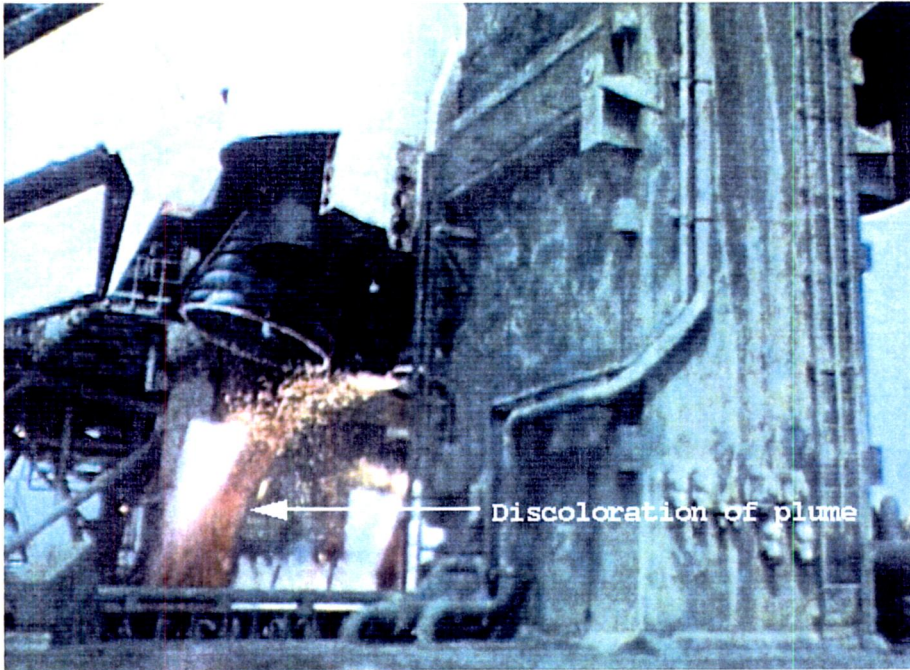


Figure 1 Orange discoloration in SSME #1 plume

A streak in SSME #2 plume was observed at approximately T+3.7 seconds MET.

Several pieces of debris were observed exiting the SRB secondary blast holes, traveling upward and across the MLP deck away from the vehicle towards the north. None of these particles were observed to strike any flight hardware.

Sound suppression water was leaking at several joints in the J-pipes along the SRB blast holes prior to liftoff.

A debris induced streak at T+37 seconds MET in the SSME plume was recorded by several tracking cameras.

Camera E220 exhibited optical distortions during the track causing dark shadows along the vertical stabilizer and the SSME plumes to fluctuate in intensity at approximately T+80 seconds MET.

V. ENGINEERING DATA RESULTS:

a. T-Zero Times:

T-Zero times are determined from cameras that view the SRB holddown posts numbers M-1, M-2, M-5 and M-6. These cameras record the explosive bolt combustion products.

HOLDDOWN POST	CAMERA POSITION	TIME (UTC)
M-1	E-9	250:15:09:00.005
M-2	E-8	250:15:09:00.005
M-5	E-12	250:15:09:00.005
M-6	E-13	250:15:09:00.004

b. ET Tip Deflection:

This analysis is planned to be eliminated unless requested. A reduction in film camera coverage is planned which includes camera item E79. Item E79 specific purpose was for this analysis. However, this analysis can be performed using other camera items but at a reduced spatial resolution. A comparison, shown in Figure 2, was made to ensure this capability.

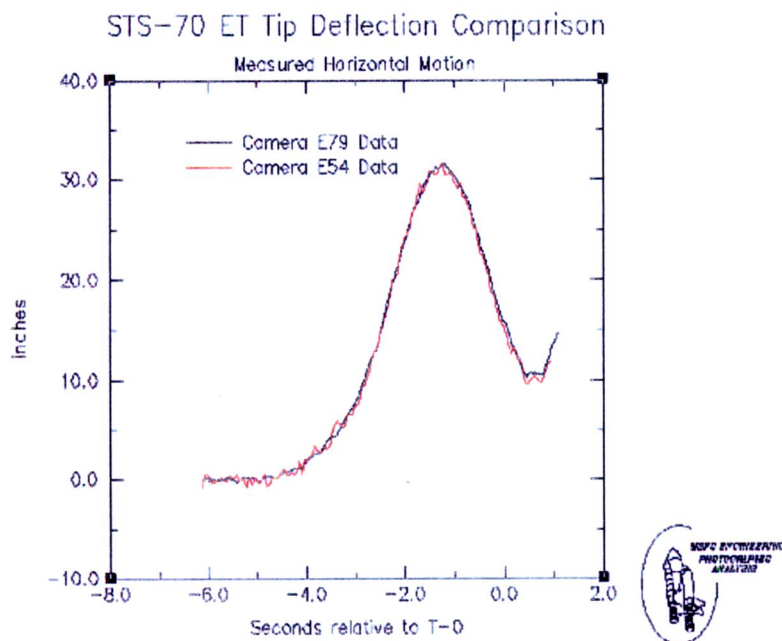


Figure 2 ET tip deflection comparison

c. SRB Separation Time:

Best estimate of the SRB separation time for STS-69 is 250:15:11:02.47 as recorded by several tracking cameras.

REPORT DOCUMENTATION PAGE

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